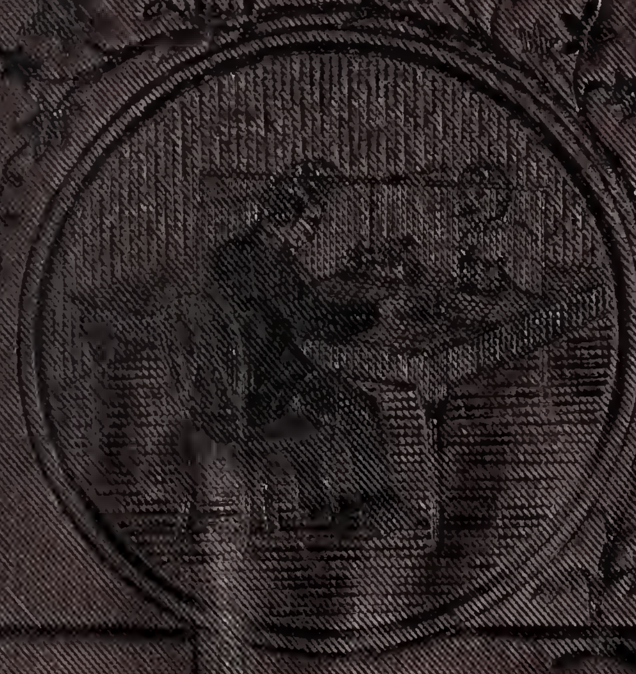
MODERN SERVICE OF COMMERCIAL AND RAILWAY TELEGRAPHY

ILLUSTRATED.



Saml. F. B. Morse.

THE MODERN SERVICE

OF

COMMERCIAL AND RAILWAY

TELEGRAPHY,

IN THEORY AND PRACTICE,

ARRANGED IN QUESTIONS AND ANSWERS.

DESIGNED FOR STUDENTS AND OPERATORS.

THIRD EDITION, REVISED AND ENLARGED.

COMPILED, PREPARED, AND PUBLISHED BY

J. P. ABERNETHY,

SUPT. TELEGRAPH.

CLEVELAND, OHIO.

1884.

Electrotyped by
Eclipse Electrotype and Engraving Co.,
Cleveland, Ohio.

Printed and Bound at
Publishing House of W. W. Williams,
Cleveland, Ohio.

PREFACE.

The preparation of this work was necessitated by the fact, that though many volumes had previously been published upon telegraphy, yet none of them were found to exhibit a thoroughly practical view of both commercial and railway telegraphy, including the railway station and express service, so brief, simple, and comprehensive, as to answer the purpose of a practical text book. In the preparation of such a text book, two things demanded constant attention; first, that the time which the telegraphic student ordinarily devotes to the theory of his profession is very limited, and, second, that such students are generally unacquainted with science. For these reasons it was necessary that the statements of the work should be very concise, and yet clothed in language intelligible to the unlearned reader. Hence scientific terms and idioms have been generally discarded, and the work made as thoroughly practical as possible, including, however, certain elementary principles of electrical science which are intimately associated with practical telegraphy, a knowledge of which should be acquired by all who aspire to recognition and position as telegraphers. Although there is almost an endless variety of contrivances for transmitting and receiving messages, involving different applications of

electric and chemical science, the author has generally confined himself to the common Morse telegraphic system, and its improvements, as it is the system principally used in the commercial and railway service. For this reason many branches of electric science have been omitted.

The method in which the work is composed (that of questions and answers), was chosen as being favorable to conciseness of statement, and at the same time, best adapted to use as a text book.

In the compilation of this work, which has involved a great deal of time and labor, much practical and valuable information respecting both commercial and railway telegraphy, and the railway station and express service, has been carefully selected from a large amount of material gathered together, from the experience of efficient operators in all grades of service, and from official as well as from other reliable sources, in connection with the most prominent telegraph, railway, and express companies in this country. Much assistance has also been gained, from the use of Prescott's admirable work, Electricity and the Electric Telegraph, Culley's Handbook of Practical Telegraphy, Jenkins' Electricity and Magnetism, several other telegraphic works and telegraphic and railway journals, and many personal favors, for all of which the author's acknowledgments and thanks are herewith respectfully returned.

CONTENTS.

PART FIRST.

THE MORSE SYSTEM OF TELEGRAPHY.

PART SECOND.

ELECTRICITY.

PART THIRD.

THE TELEGRAPH.

PART FOURTH.

COMMERCIAL BUSINESS.

PART FIFTH.

RAILWAY TELEGRAPHY.

PART SIXTH.

RAILWAY STATION SERVICE.

PART SEVENTH.

APPENDIX.

LIST OF ILLUSTRATIONS.

PART FIRST.

THE MORSE SYSTEM OF TELEGRAPHY.

SECTION I.

INSTRUCTION FOR BEGINNERS.

To acquire a thorough knowledge of telegraphy, the student should bear in mind *at the beginning* that *proper attention* must be given to the principles upon which telegraphs are operated and the apparatus employed. To become an expert operator requires much time and patience, together with unwearied application. Remember that great results cannot be expected from little labor, and whatever is worth doing at all, is worth doing well.

There is no duty of an operator which any person of ordinary ability may not readily perform, if they will but bestow the attention which they should willingly give to any undertaking.

Paper operators are now rare, and the student should learn to read by sound at once. It is as easy to cultivate the ear as the eye; reading by sound leaves the sight free to direct the hand in copying messages.

Each lesson should be mastered before another is undertaken. Nothing is gained by rushing hurriedly over the ground. No

business can be learned in a day ; and telegraphy requires careful, methodical drill and study. It is better for two or more persons to practice together, taking turns in sending.

The basis of the whole telegraphic apparatus is the *battery*, the *transmitting key*, and the *electro magnet* (each described elsewhere) ; the essential part of the apparatus being the battery, as it is from the chemical action created therein that is first generated the electric current, which is made to traverse long or short distances through the conducting medium of metallic wires.

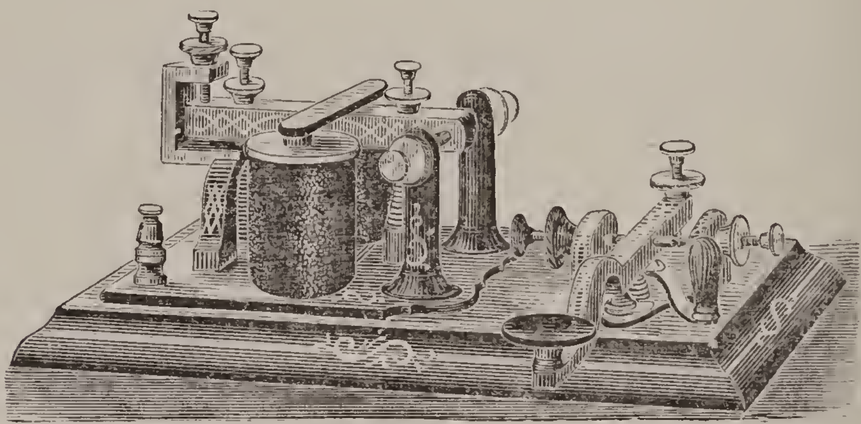


Fig. 1.

The instruments required for new beginners are practically the *Morse sounder and key*, separate, or attached to the same base, (see fig. 1), *and the battery* for generating the electricity. The instruments should be securely fastened near the center of the table used for the purpose. And, if the sounder and key are separate, the key should be placed at the right hand side in such a position that the arm may obtain a rest while sending, and the sounder placed at the left hand side. To receive the conducting wires small holes should be bored near the sounder binding posts, and larger ones to receive the legs of the key, which is then securely placed in its proper position. The instruments are then connected with the battery as follows : Starting from the battery run one wire to one of the binding posts of the in-

strument, and another wire from the opposite side of the battery to the other post of the instrument. When covered wire is used always *bare the ends* where the connections are made. If a key is used separately, cut one of the wires and fasten the ends to each leg of the key. See that all the screws are made tight, and that the sounder-lever works freely but not too far from the magnets. The spring which draws the armature lever upwards must have the right tension to allow the armature to respond to the magnet.

When the key is closed, a current from the battery will pass through the wire and magnet, and cause the latter to attract the armature, and the instant the key is opened the current will cease to flow, the magnet cease to attract, and the spring will draw the armature away. In this way the armature is made to follow exactly the movements of the key, no matter at what distance they may be placed from each other, although in practice it is found that as the circuits are lengthened more battery power is required. When additional instruments are connected in the same circuit, the "circuit-breaker" at the side of the key should always be open while sending, and *closed for receiving*, but if not in connection with other instruments, it may be left open all the time.

TO CONNECT TWO INSTRUMENTS TOGETHER FOR PRACTICE.

The return circuit may be made either by a continuous wire, or by connection with the earth at each end. For wires but a short distance in length, the return wire is best.

Starting from the respective poles of the battery, run a wire to one of the binding posts of each instrument, and then connect the remaining binding posts by a third wire. For two instruments in connection, not farther than one hundred feet apart, use two or three cells of battery, adding one cell for each additional instrument connected to the same wire.

PRIVATE LINES.

In the construction of short outdoor lines of over a quarter of a mile in length, only one wire is necessary, the earth being used for the return circuit. For such lines "No. 12 galvanized iron wire" is the least expensive wire suitable for the purpose, copper being used inside of offices and buildings, covered with a coating of gutta percha, or wrapped with a continuous covering of cotton or silk.

The only instruments required for short lines are practically the Morse sounder and key. The sounder, however, must be of the proper resistance. The resistance of all the instruments on the line should be equal to the resistance of the battery and line. For lines between one and ten miles in length the instruments are required to have their magnets wound with finer wires than those used on circuits of less than one mile. Such instruments are from 10 to 30 ohms resistance, according to length of line.

The gravity battery is used for short lines, and should be placed in connection with the line between the instrument and ground connection, all at one end of the line, or part at one end and part at the other.

If it is found when one or more instruments are properly connected in a circuit according to directions, it or they do not work with enough strength to give the amount of sound wanted, addition of more battery will produce better results. Add one cell for each quarter of a mile added to the length of the wire up to one mile, and then two or three cells for each additional mile.

NOTE.—For further information regarding "lines" see Section "XXI."

SECTION II.

MANIPULATION.

Manipulation or sending is the operation of forming telegraphic signals upon the instrument called the key, by means of which, when in connection with the proper instruments and battery (herein described), is made to give out audible signals, which, being arranged in the form of an alphabet, enables us to read or speak, as it were, from a distance.

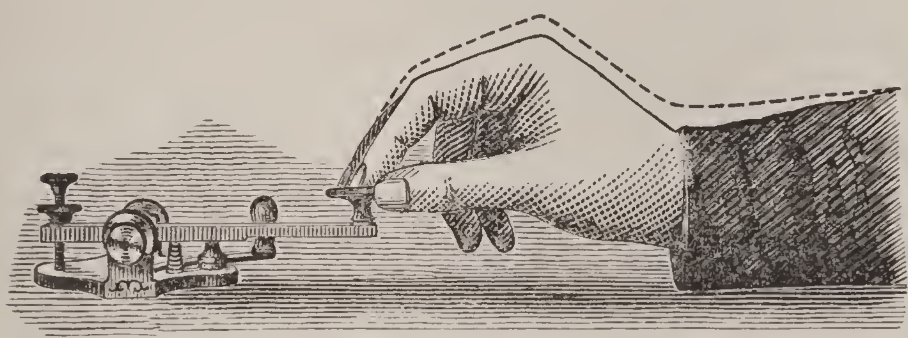


Fig. 2.—POSITION OF HAND AND MOVEMENT.

Manner of holding the key.—Place the first two fingers on the top of the key knob with the thumb under the edge, and the second finger a little on the opposite side; curve the first and second fingers so as to form the quarter section of a circle, partially close the third and fourth fingers (see Fig. 2), allow the wrist to be perfectly limber. Rest the arm on the table at or near the elbow; let the grasp upon the key be firm but not rigid; never allow the fingers or thumb (while sending) to leave the key, nor the elbow to leave the table; avoid too much force or too light touch, and strive for a medium, firm closing of the key. Learn to handle the key as easily as you would a pen.

The motion to be imparted is directly up and down, avoiding all side pressure.

The movement is made principally at the wrist, although the finger and hand must be perfectly elastic.

The fingers, wrist, and arm should move uniformly in the same direction.

The downward movements produce the dots and dashes, and the upward the breaks and spaces.

Tapping upon the key should be carefully avoided.

Never attempt to write with a *finger* movement. The fingers should be used merely to grasp the key.

SECTION III.

THE MORSE TELEGRAPHIC ALPHABET.

Morse, in the arrangement of his conventional telegraphic alphabet, took as a *unit* of space or length the shortest available length of line, technically termed a *dot*. His alphabet was then made up of signs, forty-five in number, formed from three elements, the DOT, the SPACE, and the DASH, arranged in various combinations representing the following relative values:

The dot	One unit
The space or break between the elements of a letter	One unit
The space, employed in the "spaced letters"	Two units
The space separating the letters of a word	Three units
The space separating words	Six units
The short dash	Three units
The long dash	Six units

"Prof. S. F. B. Morse, in considering the mechanical means at command for producing at a distance any permanent mark, perceived that by means of the electro-magnet the motion of a lever, up and down, could be easily and surely commanded; and if a pencil at one extremity of it were made to strike upon a piece of paper, a dot would be made whenever the magnet

was charged and quickly discharged. This action, however, without a further device, would be unavailing to produce variety since the lever motion is limited to the simple movement of up and down. Hence the idea of moving the paper at a regular rate beneath the pencil. Thus a dot could be made on the moving ribbon of paper, which, passing onward, the paper was ready to receive (after an interval more or less extended) another dot or series of dots. Thus the ability to produce dots in groups at pleasure was demonstrated, and, consequently, groups of dots expressive of various numerals were devised. In pursuing the experiments with the numerals whose elements were a simple *dot* and *space*, it was perceived that, by means of the moving paper, not merely a dot could be produced at pleasure, but if the magnet was kept charged while the paper was in movement, the pencil produced a line long in proportion to the time in which the magnet was charged. This fact introduced a *third* element for combination, to produce variety in the groups, indicating letters as well as numerals, to wit: the line or dash; so that *dots*, *spaces*, and *lines* in any variety of combination were at command for forming a code of signs. Hence originated what is now universally recognized as the Morse code."

In the arrangement of the alphabet it was desired that no letter should occupy more than five dots, or nine units in length; and none of them, with the single exception of the letter J, exceeds that number. Another principle was specially observed, that of the letters occurring most frequently in the English language, were therefore composed of the fewest and shortest elements. The letter E is thus represented by a single dot; the I and T within the space of two dots or three units, and so on. The numerals were comprised within the value of six dots, or eleven units, to distinguish them more readily from the letters.

The dot, the unit of length in the alphabet, though in reality a short line, representing the letter E, is produced by a firm downward movement of the key-lever, immediately succeeded

by a quick upward motion. The combined duration of these movements should about equal the time occupied in pronouncing the word *it*, care being taken not to delay the upward motion, thereby prolonging the dot into a dash.

The space is produced by the upward movement of the key; the *four* different kinds of spaces employed indicating the *intervals* or length of time the key should be raised.

The break is the instantaneous interval between the elements of a letter, produced by the quick upward and downward movement of the key, separating the dots and dashes from each other. The downward position of the key must always be taken for the commencement of the following dot or dash, comprising a letter. It must be continually borne in mind that every character not containing a space, must be compact, and not open and disjointed, so as to entirely change the meaning by a division of one character into two or more shorter ones.

The spaced letters, six in number, viz: C, O, R, Y, Z, and &, termed spaced letters because they contain a space in the body of the letter, equal to two units or *one dot* and break. They were thus arranged with the intention of securing economy of space and time, but they possess the practical defect of being liable to be confounded with other letters or combinations of letters, unless very carefully transmitted. These letters cause the most telegraphic errors, although the number of words in the English language which are liable to be mistaken for each other when written in this way are very small; however, it should be remembered that words containing spaced letters must be transmitted with caution, and such letters made plain, separate and distinct.

The space between the letters of a word is equal to three units or *two dots and breaks*. An exception to this rule, however, is made in double E, which must contain a space nearly as great as that between words, and double L, or two or more ciphers

need not be spaced, as when properly made they cannot be mistaken for anything else.

In words largely composed of dots and spaced letters, the spaces should be more than usual between the letters, viz:

Seen	Erie
- - - - - — -	- - - - - - -
Receive	Cicero
- - - - - - - - - - - - — -	- - - - - - - - - - - - - -

Uniformity of *space between letters and the correct proportion of letters themselves, is of great importance*, especially in regard to Ta and K, An, We, and figure 1, Me and G, Te and N, Ti and D, Th and 8, Ts and B, St and V, It and U, In and Q, At and W, and the letters Ke and J.

If properly made the ear of a practical operator will readily distinguish the telegraphic signals, however rapidly they may be transmitted. The sense of a message is often entirely changed by bad spacing.

The space between words is equal to *six units or three dots and breaks.* A very common fault is to run the words too closely together, which causes more trouble in reading than any other one feature of poor transmission. Uniformity of space between words is of as much importance as between the letters. However rapid the writing the various spaces should have the same relative length. Double the usual space should be left between initials, and, in large numbers, a short space is usually made between every three figures.

1,000. - — — - ——— ——— ———

1,500. - — — - — — — ——— ———

18,507. - — — - — - - - - — — — ——— — — - -

21,369. - - — - - - — — - - - - — - - - - - - - — - - —

The short dash is equal to three units or three dots. When uncombined it represents the letter T, but enters into various

combinations, however, with the dot or with itself. It is produced by holding the key down as long as it takes to make three dots, or in other words holding the key lever down long enough to pronounce the word *seat*, taking care that the upward movement does not occur until the final sound of the word has been fully completed. In the attempt to write fast the tendency is to make the dash too short; this should be carefully guarded against with the utmost vigilance.

The long dash is equal to six units or six dots. When used as an initial or when joined with other letters, it always represents L; but when found with figures it is always a cipher. The long dash is never used in combination. The original intention was to use a longer dash for the cipher, prolonging it so as to occupy the time required for nine dots, but practice has made no difference in them. The general tendency is to make the L dash too short, even by advanced students and practical operators, thereby causing many errors through misinterpretation for M or double T. It is better to make the L dash a little too long than too short, as then it cannot be mistaken.

SPECIAL NOTICE.

In telegraphic manipulation the law of intervals, and length of time, is just as essential as in music. However rapid the writing the various spaces, dots, and dashes must be uniform and proportionate to each other or the characters will be imperfect. The unit may vary in length according to circumstances, but the elements should always have the same relative value. For instance, in working over a long circuit, especially when wires are working hard, it is often necessary to make the *dot* longer perhaps than the *dash* is made under ordinary circumstances. In such case the spaces and dashes should have a corresponding length. In writing, the fingers should not be removed from the key during the short intervals, but the thumb

should pull up gently on the button when the spaces or breaks occur.

Each character of the alphabet should be thoroughly *impressed on the memory* without reference to the position of other letters before commencing to practice them. When once the principles and characters of the alphabet are thoroughly understood and impressed on the memory, so that the mind has nothing to do but attend to the mechanical movement, the process of learning at the instrument is easier and more rapidly acquired.

The following characters will be found to be the reverse of each other. They should be memorized so that *each* can be called to mind at will without hesitation:

A - — and N — -, B — - - - and V - - - —, C - - - and R - - -, D — - - and U - - — G — — - and W - — —, J — - — - and Comma - — - —, Q - - — - and X - — - -, Z - - - - and & - - - -, and figure 4, - - - - — and 8 — - - - -.

SECTION IV.

EXERCISES IN MANIPULATION.

After the student has attained proficiency in the elementary principles, the following exercises should be practiced in regular order. Each character repeated over and over until it can be made correctly at will. In no case *should the student attempt the practice of the letters in alphabetical order*; neither should he endeavor to write his name nor any other words, until he has *thoroughly mastered these exercises.* In the first exercise dashes are given, in order that the habit of writing firmly may be acquired at the very start. When the first exercise consists of dots, the student is liable to form a habit of making short, light dots, or "clipping," which he will find very difficult to overcome. Firm,

steady sending should be attained at any expense of time and practice. The prevailing idea among beginners, is that it is an easy matter to learn to send, and that rapidity in sending, and proficiency in receiving, or reading by sound, is all that is required, hence neglect the necessary careful practice to attain proficiency in sending, but instead acquire a careless habit by attempting to send too fast, with an utter disregard of uniformity and proportion of the characters to each other. An excellent rule for beginners is to *limit* their sending to one-third *more* than they can receive by sound and never to attempt to send faster.

As it is better not to practice the alphabet in regular order the letters are placed in the following exercises in groups, each of which forms an exercise, which should be practiced until thoroughly mastered before commencing the next. Nearly every new beginner has his particularly hard letter to overcome, and finds it necessary to keep practicing on it for hours to train his fingers to make it correctly.

In order to make the letters correctly, perfect control of the use of the key is very desirable, hence the fingers should be trained to its use, and each exercise repeated over and over again until the finger joints seem to relax, and perfect control of the key is gained.

FIRST EXERCISE.

DASHES IN SUCCESSION.

Commence by making a succession of dashes, first at the rate of about one per second, which may be afterwards gradually increased to two or three. Special care must be taken to make the *break* between the dashes as short as possible. If a full movement be employed, the dashes cannot be too close to each other. The tendency is always to introduce too much space between the dashes; great care must be taken to over-

come this, remembering that every character not containing a space must be compact and not open and disjointed.

— — — — — — — — — — — —

Separate dashes representing the letter T, and L, or cipher. Do not make T too long, or L too short.

—   —   —   —   —   —   —   —

——   ——   ——   ——   ——   ——

SECOND EXERCISE.

DOTS IN SUCCESSION.

Commence by making a succession of dots with as much regularity as possible, at the rate of about five per second, increasing the speed as skill is acquired, until they are produced with the regularity of clock-work, and of definite and uniform duration. The tick of a watch or clock will assist in doing this.

- -

Separate dots representing the letter E.

-   -   -   -   -   -   -   -   -   -   -   -

THIRD EXERCISE.

DASH LETTERS.

T	M	5	L or cipher.
—	— —	— — —	——

In practicing this exercise care should be taken to proportion the short and long dashes accurately, and in making the characters which consist of more than one dash special care must be taken that they follow each other as closely as possible, and that the final dash in each letter should exactly equal the preceding ones. Beginners usually make the final dash too short.

FOURTH EXERCISE.

DOT LETTERS.

E	I	S	H	P	6
-	- -	- - -	- - - -	- - - - -	- - - - - -

Practice these separately until the right number of dots can be made. Let the dots be of equal length; beginners are very liable to prolong the last dot into a dash. This may be avoided by making the last dot with a movement *seemingly* quicker than that employed for the others. When each signal can be made perfectly, and represented exactly by the right number of dots, write them in succession a number of times forward and backward, making each but once before proceeding to the next.

FIFTH EXERCISE.

A DASH CLOSELY FOLLOWED BY A DOT REPRESENTING THE LETTER N.

—. —. —. —. —. —. —. —.

This exercise will be found more difficult. Beginners are liable to shorten the dash and lengthen the dot, producing the letter A. But the greatest obstacle to be overcome is the tendency to prolong the break, thus producing Te. Remember that the downward position of the key must be taken as the starting point for the dot. The movement may be timed by the pronunciation of *nine-ty* slowly, dwelling on the first syllable somewhat.

SIXTH EXERCISE.

A DOT WITH A DASH CLOSELY FOLLOWING REPRESENTING THE LETTER A.

.— .— .— .— .— .— .— .—

In this exercise there is a strong tendency to separate the dot from the dash by a prolonged interval, and also to make the dot too long and the dash much too short. The movement may be timed by pronouncing the word *against* with a strong accent upon the last syllable. The final sound (st) should represent the upward movement terminating the dash.

SEVENTH EXERCISE.

SPACED LETTERS.

O	R	&	C	Y	Z
- -	- - -	- - - -	- - -	- - - -	- - - -

These are termed spaced letters, and require great care to make them correctly. The space should be just double that ordinarily used between the elements of a letter. The usual tendency is to make it too great. It should only be sufficient to distinguish these characters from I, S, and H.

EIGHTH EXERCISE.

DASH, WITH DOTS, IN SUCCESSION.

N	D	B	8
—-	—--	—---	—----

Having thoroughly mastered the preceding exercises, the student will have no difficulty in forming the above characters. Make them as in I, S, H, and P, prolonging the first dot. Avoid leaving any space between them, and be careful not to make the last dot a dash.

NINTH EXERCISE.

DOTS, WITH A DASH IN SUCCESSION.

A	U	V	4
-—	--—	---—	----—

The usual tendency to make too much space between the dot and dash in the above letters may be avoided by making them as if prolonging the final dot in I, S, H, and P. Counting the dots and prolonging the last one is of aid in practicing this exercise. Always make the dots close together, and let the dash follow the dots as closely as possible. Avoid making the dash *too short.*

TENTH EXERCISE.

CHARACTERS GROUPED TOGETHER.

I	A	N	S	U	D	H	V	B	P
- -	- —	— -	- - -	- - —	— - -	- - - -	- - - —	— - - -	- - - - -

4	8
- - - - —	— - - - -

These should be practiced in groups, as arranged in this exercise, the object being to impress on the student the difference in the characters thus grouped together.

ELEVENTH EXERCISE.

DASHES AND DOTS IN MIXED COMBINATION, EACH COMMENCING WITH A DASH.

G	7	K	J	9	Interrogation
— — -	— — - -	— - —	— - — -	— - - —	— - - — -

Special care must be taken to make these characters compact, and the dashes to correspond in length. K and J, are generally considered the most difficult letters in the alphabet. The tendency is to separate K into N T, and J into double N. This may be overcome by forming a close combination of T A for K, and T F for J, and figure 9 may be formed from T U, and interrogation from T Q. Do not make D for K. Drill upon this exercise until perfection is attained.

TWELFTH EXERCISE.

DOTS AND DASHES IN MIXED COMBINATION, EACH COMMENCING WITH A DOT.

W	F	X	1	Comma
- — —	- — -	- — - -	- — — -	- — - —

The principal caution necessary in this exercise is to form the letters compactly, with the dashes of proper and equal length. Do not separate W into A T, X into E D, or make F for W.

THIRTEENTH EXERCISE.

DOTS AND DASHES IN MIXED COMBINATION, EACH COMMENCING WITH DOTS.

Q	3	2	Period
- - — -	- - - — -	- - — - -	- - — — - -

These require no particular directions, except the caution to form the letters compactly, and to make the dashes of proper length. U E, when connected together, will form Q; V E, figure 3; U I, figure 2; and U D, the period.

FOURTEENTH EXERCISE.

ADDITIONAL PUNCTUATIONS.

Exclamation	Quotation	Paragraph
— — — -	- — - — - — - —	— — — —
Semi-colon	Parenthesis	Italics
- — - — -	- — - - —	— - - - — -

These punctuations complete the Morse characters, but the semi-colon, parenthesis, and italics are but little used on the American lines, particular words being emphasized by separating the letters a little more than usual, but when the quotation, parenthesis, or italics are used they precede and follow the words to which they belong. The paragraph signifies begin another line. On the Associated Press lines, between New York and Washington, certain combinations of letters, not liable to be confounded with anything else, are substituted for the following punctuations:

Semi-colon	"ie"	Dash	"dx"
Colon	"ko"	Parenthesis	"pn"
Quotation	"qn"		

The following character - - — — has recently been proposed, and to some extent adopted, for the cipher, instead of the dash, to distinguish it from the letter L. Its general adoption,

or some other convenient character, not liable to be confounded with others, would seem to be desirable.

FIFTEENTH EXERCISE.

FRACTIONS.

Fractions are made by substituting a dot for a hyphen between the figures.

1–2	1–4
- — — - - - - — - -	- — — - - - - - - —
1–3	3–5
- — — - - - - - — -	- - - — - - — — —
7–8	9-10
— — - - - — - - - -	— - - — - - — — - ——

11–12

- — — - - — — - - - — — - - - — - -

No sign for dollars or cents is employed, consequently these words must be written out in full—indeed nothing can be telegraphed which cannot be spelled.

Practice the preceding exercises thoroughly, forward and backward, and by selection, until every character can be made at will correctly, before practicing them in alphabetical order.

No mental effort whatever is required of a practical operator to construct a Morse letter the moment his eyes come to it.

SECTION V.

THE MORSE AND THE CONTINENTAL OR INTERNATIONAL ALPHABET.

MORSE ALPHABET.

A	B	C	D	E	F	G	H
·—	—···	·· ·	—··	·	·—·	——·	····

I	J	K	L	M	N	O	P
··	—·—·	—·—	——	——	—·	· ·	·····

Q	R	S	T	U	V	W	X
··—·	· ··	···	—	··—	···—	·——	·—··

Y	Z	&
·· ··	··· ·	· ···

NUMERALS.

1	2	3	4	5	6
·——·	··—··	···—·	····—	———	······

7	8	9	0
——··	—····	—··—	——

PUNCTUATIONS.

Period.	Comma.	Semi-colon.	Quotation.	Parenthesis.
··——··	·—·—	·—·—·	·—·—·—·—	·—··—

Interrogation.	Italics.	Paragraph.	Exclamation.
—··—·	—···—·	————	———·

CONTINENTAL OR INTERNATIONAL ALPHABET.

(Not used in America.)

Upon the introduction of the Morse system into Germany many years ago, an important arrangement of the alphabet was devised, called the *Continental or International Alphabet*, and this has been adopted and become universal on all submarine cables as well as land lines, in all parts of the world where the

Morse apparatus is used, *except in America.* It is founded on the Morse, and the only letters that differ from the Morse are c, f, j, l, o, p, q, r, x, y, z,—the additional letters peculiar to foreign languages are ä (æ), ö (œ), ü (ue), eh é, ñ. The figures are all different except the figure 4. All these letters and figures are made by dots and lines the same as the Morse, and only differ in their relative position.

THE CONTINENTAL ALPHABET.

LETTERS.

A, - —	J, - — — —	S, - - -
B, — - - -	K, — - —	T, —
C, — - — -	L, - — - -	U, - - —
D, — - -	M, — —	V, - - - —
E, -	N, — -	W, - — —
F, - - — -	O, — — —	X, — - - —
G, — — -	P, - — — -	Y, — - — —
H, - - - -	Q, — — - —	Z, — — - -
I, - -	R, - — -	
CH, — — — —	Ü, - - — —	
Ä, - — - —	É, - - — - -	
Ö, — — — -	Ñ, — — - — —	

NUMERALS.

1, - — — — —	5, - - - - -	8, — — — - -
2, - - — — —	6, — - - - -	9, — — — — -
3, - - - — —	7, — — - - -	0, — — — — —
4, - - - - —		

PUNCTUATION, ETC.

Period, - - - - - -	Inverted Commas, - — - - — -
Comma, - — - — - —	Fresh Paragraph, - — - — - -
Interrogation, - - — — - -	Understand, - - - — -
Exclamation, — — - - — —	Wait, - — - - -

Apostrophe, - — — — — - Erase, - - - - - - - - -
Hyphen, — - - - - — Call Signal, — - — - — - —
Parenthesis, — - — — - — End of Message, - — - — - — -
I don't understand, - - — — - - - - — — - -
Cleared out all right, - — - - — - - — -

The accented é is important in French to distinguish between the past participle and the present tense. The apostrophe is equally necessary in French, thus: C'est l' intention de l' Empereur, etc. The ä ö ü are important in German. The Spanish ñ is seldom used. The period (.) is generally written in three pairs, the mind counting three more easily than six, thus - - - - - - The erasure is frequently divided into three threes, and for the same reason, thus: - - - - - - - - - It is used as follows: Suppose the operator to have misspelled a word, he gives the nine dots (the eraser signal), goes back to the word before the error, repeats it, and continues.

It will be noticed that in the international code each numeral is composed of five elements, systematically arranged, the first half checking the second half of the character, and so rendering them as free from ambiguity as they are easy of recollection by the mind.—*Prescott.*

SECTION VI.

SENDING.

When proficiency has been attained in the preceding exercises, the transmission of words and sentences may next be taken up; small words at first, and then short sentences for practice, always being careful to write one correctly before commencing another. Great benefit may be derived from considerable practice upon such combinations as *tel*, *let*, *little*,

lake, *train*, *jaw*, *knoll*, *knot*, *need*, *nod*, *ice*, *rice*, *person*, *poison*, *Mississippi*. If a mistake is made in any letter of a word, *always* repeat the word until written correctly, and always remember the rule in regard to spacing between letters and words. Practice sending words and sentences from memory as well as from looking at a copy. Send slowly and carefully at first, striving for *accuracy* rather than speed. Speed will come by practice. Cultivate a firm, even, smooth style of sending. The fast, careless senders do not dispatch the most business. Graduate your sending to the capacity of the receiver, and never crowd him.

The custom of *timing* for the purpose of ascertaining rate of manipulation, should be very sparingly indulged in by the student, except under the direction of his or her instructor; it is apt to induce careless habits. There are almost as many styles of sending among operators as of penmanship. It is quite possible on a line where a number of operators work, to tell each one by his manner of manipulating the key. All have their peculiarities.

There are few operators capable of sending and receiving forty-five words per minute. Forty words is very rapid work. The average speed does not reach thirty words. Probably the average is about twenty-five words; and of the faster wires thirty words per minute. A *careful* and *correct* style of transmission, however, is regarded as of *far more value* than mere rapidity.

SECTION VII.

"RECEIVING," OR READING BY SOUND.

When the letters of the alphabet are thoroughly impressed upon the memory, and the mechanical movement so thoroughly acquired that the student can *send* readily and correctly, reading by sound may next be taken up. As one cannot read by sound from his own writing, it is necessary for another person to ma-

nipulate the key which operates the sounder, making the letters, while the other by listening endeavors to name them. The one who writes on the key, however, *must* make the signals distinctly and correctly, or they cannot possibly be distinguished by the other. The best result is obtained by a practical operator manipulating the key, although good practice can be obtained by two beginners practicing together, taking turns at reading and sending, and each correcting the faults of the other.

It should be remembered that there is no change in the tone of a sounder, the letter being determined solely by the "time or times" the lever is up or down. The movement of the lever to and from the magnet between the screws and striking against them produces the sounds, representing dots, dashes, and spaces, the downward movement the dots and dashes, the upward movement the breaks and spaces, the duration of each controlled by the key which opens and closes the circuit. The back stroke, so-called, is as necessary to reading by sound as the down stroke, and these must be distinguished each from the other, for without it the duration of the downward movement could not be determined.

In reading by sound the practice should commence by receiving *letters* by sound and copying them, continuing this practice until each letter is recognized instantly, then practice receiving *entire words*, slowly at first, and from that to *slow writing*, gradually increasing the speed, until capable of receiving and copying rapid writing.

If a word is missed or not received correctly, open the key and repeat the last word received. If every word is missed or not received correctly, open the key and say "RR" [meaning repeat]. Don't be afraid or ashamed to "break" or ask for information—better fifty breaks or questions than one error.

The beginner should early accustom himself to copy that which he receives, keeping as far *behind transmission* as possible.

This necessarily divides the attention and requires the exercise of the memory, hence somewhat difficult to attain, but it *must be accomplished* to become a good receiver of rapid "sending." An expert operator never proceeds to write down what he receives until *several words have been transmitted.* He then copies the first part of the message while receiving the latter part. Of course the student will not be able to accomplish this without unwearied application. At first the ability of keeping only a word or two behind will be attained, but persistent practice and experience will accomplish much.

When able to make a legible copy at an average of eighteen or twenty words per minute, the student should practice on a short circuit, *or on a regular line*, if an opportunity is given, in taking regular commercial messages, press, market reports, train reports, train orders, etc., etc., in order to become thoroughly accustomed to actual business forms, and secure the necessary experience which only can be acquired by office practice.

To acquire the ability of distinguishing between the confusion of noise made by a number of line instruments at work, requires much practice, and the beginner should lose no opportunity to acquire skill in this direction.

It is by far easier to learn to send a message than to receive one, and the ability of reading by sound far easier than conveying at the same time to paper the words ticked off by the instrument, hence constant and persistent practice is *absolutely necessary* to success.

When the student finds himself capable of sending and receiving promiscuous messages at the rate of thirty words, he may begin to look about for an office. The local peculiarities of doing business upon different lines are very great. When practicable, the student should spend several weeks in an office, familiarizing himself with the rules, forms, and methods of the line before attempting the management himself.

Poor operators are termed "plugs."

SECTION VIII.

PENMANSHIP.

A good and legible business handwriting is a valuable acquisition in any occupation, but especially so with the telegraph operator, hence the telegraph student is earnestly advised to neglect no opportunity for acquiring skill in this direction.

The Journal of the Telegraph, in speaking of penmanship, says: In active life, good, legible business penmanship, based upon the business experience of modern times, *is what is required*, instead of the ornamental style of graceful and shaded curves which is taught by the majority of writing teachers in schools and "*Business Colleges.*" What is needed is to make the letters in writing of the shortest length practicable, and without curves where it is possible to retain the contour of letters without it. Hold the pen as close to the paper as possible, and make as little motion as possible, and never try to shade letters or to make graceful and ornamental curves. Write all capital letters very plain and all numerical figures distinctly, and write all proper names and abbreviations distinctly and carefully. This is because there is generally no means of ascertaining them by the sense. You are insured of rapidity, and it may be said general gracefulness when you make letters in the shortest and easiest way possible, as above suggested; this, with the proper names and figures distinct, will render such writing easily read. The usual indistinctness of numerical figures in writing has led telegraph companies to require all numbers to be spelled out both in receiving and sending messages, to avoid frequent errors in them. Punctuation is also important as well as the use of capital letters, to aid in ascertaining the sense of words. Ornamental penmanship is as much out of place in a telegraph message as it would be to waltz to your place of business instead of directly stepping

there. Business penmanship is not as much taught in schools and colleges as it ought to be, and hence a person must be his own teacher in a great measure, and learn by experience and observation the manner and style which is the easiest and best for himself to insure the most rapid and readable hand, and not be guided by mere imitation, as is characteristically the case in ornamental penmanship. Nearly all telegraph operators are required to be able to write from twenty to thirty words a minute, and a few have even been able to write fifty short words a minute so it could be read without being copied over by the receiving operator. In large business centres the copying over of a telegraph message is not expected or generally allowed.

Our closing advice is, let your letters be made plain, well defined and brief, without curves and flourishes, and it will be a blessing and not a curse to all who have to do anything with it. As further reliable authority on the subject we herewith present the following instructive extract from an article entitled: *Bad Writing—Its Cause, Effect and Correction*—Prepared for *The Penman's Journal* by the well-known artist, penman and expert, Mr D. T. Ames, of New York, and subsequently published in the *Journal of the Telegraph*, in the hope that it would prove useful and instructive to many telegraphers, and aid in protecting the telegraph service against that fruitful source of errors which are charged to the telegraph—careless and illegible handwriting.

With the view of placing before the readers of this journal some reliable facts and statistics upon this point, we have lately visited several important and extensive establishments, and gathered such practical and valuable information as we were able bearing upon our subject, which, added to facts within our own somewhat extensive experience and observation during upward of thirty years as teacher, author, and publisher of penmanship, we here present, thus setting forth many of the most frequent and fruitful sources of bad writing and its results, fol-

lowed by several suggestions as to the manner in which they may be avoided and corrected.

One most observable fact is, that illegible and essentially bad writing is far from being confined to ignorant and unskillful writers, as we have frequently met with skillfully executed and highly artistic writing which was, in the words of Sheridan, 'curst hard reading."

It is safe to say that a very large proportion of errors in writing come from sheer carelessness on the part of the writers, which is manifest in the awkward, nondescript or uncertain forms which are employed—forms, often most easy and graceful, but which, taken separately, represent no intelligible character, and, apart from the context, are liable to be mistaken for any one of several letters that are similar in their construction. This fault is specially grievous where it occurs as an initial letter, in short names, abbreviations and cipher-writing, as in such cases a context furnishes the reader little or no aid.

Another prolific source of annoyance and not infrequently illegibility, arises from the inexcusable use of flourishes and superfluous lines; we say *inexcusable*, because at best, they mix and confuse the writing, and, when hurriedly and carelessly made, they frequently take forms which are liable to be mistaken, by the reader, for letters or parts of letters, and thereby puzzle and annoy, if not entirely change the intent of the writer. Another frequent fault is the personal eccentricity which leads a writer to adopt as *their style*, forms for letters, and especially capitals and in autographs, which are entirely outside the pale of any known system of writing, and whose identity can only be guessed at by those familiar with *their style*.

Probably no organization in the world, during some years past, has had a more extensive experience with handwriting than the Western Union Telegraph Company, or one that has experienced more forcibly the need of good writing, employing as it does nearly 20,000 operators, who transmit annually over

35,000,000 messages, each of which is required to be twice written and read, making annually over 70,000,000 different pieces of manuscript, for a correct disposition of which the company is responsible. We lately visited, at the Central office, the general operating department, which is a spacious and commodious hall occupying an entire floor of the company's magnificent building on the corner of Broadway and Dey street. In this department are constantly employed over 400 operators, who receive and transmit daily an *immense number* of messages; each message having to be twice written.

It is not to be supposed that all this is done without many annoying mistakes, resulting often in controversy, and, sometimes in costly litigations, to say nothing of the loss of time and petty annoyance in the deciphering of doubtful or unintelligible writing. Such being the fact, it is to be supposed that, as a matter of necessity, every practicable means would be used to reduce this annoyance and loss to the lowest minimum possible by seeking the sources of and prescribing a remedy for, bad writing. We made the object of our visit known to one of the managers of this department and solicited the benefit of his experience respecting the sources of bad writing, and the most effective means he had discovered for its prevention. He replied that first of all every candidate for a position as an operator must write a good, legible hand, before securing an appointment in the department; and that he was then provided with certain rules which he was requested to observe in all his writing. These rules were a summary of many years' observation and experience in practical telegraph work. They may, therefore, be said to be the outgrowth of the necessity, and an embodiment of the unparalleled experience of a great corporation, all of whose vast operations are singularly dependent upon the accuracy and celerity of handwriting.

RULES TO BE OBSERVED IN PENMANSHIP.

Rule First.—All unnecessary, superfluous or flourished lines must be omitted.

Rule Second.—No capital letters or words should be joined together.

Rule Third.—Capital letters should not be joined to the smaller letters.

Rule Fourth.—The capital T should never be looped at the top, as for instance *Seventy* is liable to be taken for *Twenty* and *vice versa.*

Several expensive litigations have grown out of the delivery of the latter combination, as Seventy when it was written for Twenty, or *vice versa*, by the sender of the dispatch.

Rule Fifth.—A capital H should never be so made as to be mistaken for an A or other combination.

Rule Sixth.—Cross all t's with a single horizontal line at the top.

Rule Seventh.—The capital I should always be made above the line, while the J should extend below. Otherwise, when used as initials or in cipher writing they cannot be distinguished with certainty.

Rule Eighth.—The small s should never be made with the loop below the line, as it is liable to be mistaken for a p or f.

Rule Ninth.—The letter Q should not be made the same as the figure 2. This is liable to become troublesome in cipher or code writing. Where letters and figures are used arbitrarily and separate, the proper distinction may be made by commencing the figure with a dot or very small oval, or as suggested by Mr. Downer, the Q may be made after the fashion of the Roman capital letter, thus, Q.

To the above rules we would add—

Rule Tenth.—No letter should have a doubtful form, such as may be mistaken for one of several letters.

Rule Eleventh.—Letters should be connected in their parts, and with other letters, by the proper and characteristic curved or straight lines. It is a very common and grievous fault in writing that a straight line or the wrong curve is employed in the construction and connection of letters, thus leaving them without distinctive character, or imparting one which is false and misleading.

In cases where the context does not determine, its identity becomes a mere matter of guess, and when extended, is still more vague and uncertain. With a properly trained hand no more time or effort is required to impart the true and unmistakable characteristics to each letter than to make forms whose identity is open to doubt and conjecture.

Rule Twelfth.—All eccentric forms and conspicuous personal oddities, which so often render writing, especially autographs, illegible, should be avoided.

Such outlandish and meaningless scrawls are simply a nuisance, and are discreditable to their authors, who, however, often seem to be under a delusion that their idiocy is a mark of genius. And yet persons who send such writing to telegraph offices for transmission are loudest in censure of the poor operators if an error is made.

Rule Thirteenth.—Adopt as a standard one plain, simple form for each letter, capitals and small, of the alphabet, and persistently make that form and no other.

It is an obvious fact that most—and especially young—writers vacillate between from two to six different forms of the capitals, and as many as are possible in the small letters, apparently in the belief that variety is the chief element of good writing, which is a double mistake, as it detracts from the good appearance of the writing at the same time that it enhances the difficulty of learning and of executing it. Between many systems and multitudinous forms of letters a writer must fail of becoming expert and skillful. He has too much to *learn* it well, and, like

"jack of many trades," must fail. The ease and rapidity with which writing can be executed, depends largely upon the simplicity of the forms of letters used and the size of the writing. *A medium or small hand is written with much more ease and rapidity* than a large hand, from the fact that the pen can be carried over short spaces in less time and with greater ease than over long ones, and can execute simple forms more easily and rapidly than complicated ones. It is a somewhat prevalent idea that good writing is a "special gift;" this idea is not only fallacious but is exceedingly pernicious, inasmuch as it tends to discourage bad writers by leading them to believe that not having "the gift" they are debarred from becoming good writers. Good writing is no more a gift than good reading, spelling, grammar, or any other attainment, and in the same way it is, and *can* be, acquired, *viz.*, by patient and studious effort. Writing is no less a subject for study and thought than any other branch of education. The correct form and construction of writing must be learned by study, while practice must give the manual dexterity for its easy and graceful execution. The hand can never excel the conception of the mind that educates and directs its action.

SECTION IX.

THE REQUISITES FOR A FIRST-CLASS OPERATOR.

Very few who contemplate becoming practical telegraph operators have any idea of the proper qualifications necessary to make a capable operator. The popular idea seems to be, that to learn the telegraphic alphabet and be able to transmit and receive a specified number of words per minute constitutes a standard of excellence and is all that is necessary. To be sure, a proper knowledge of the alphabet and a *thorough knowledge of the Morse system* is of the *first importance*, but a good operator

can hardly be gauged by the number of words he sends or receives. Speed, when combined with other qualifications is certainly a very desirable accomplishment, but we desire to impress upon the minds of beginners that it is not the first requisite of telegraphic skill—it is the steady gait and sound judgment that tells. However, on a pure question of manipulation an operator who could sit down at any time and always calculate upon disposing of from two thousand to two thousand four hundred words an hour, send or receive, making every letter unmistakably legible, might be classed strictly first-class.

To constitute a really first-class operator, however, much more is required than the mere facility of sending and receiving telegraphic signals. The telegraph needs thorough men and women not specialists.

To become an expert operator, that is a valuable one to the company, requires the possession of many qualities. In order to be properly qualified "to discharge intelligently and advantageously the duties which are likely to devolve upon one assigned to a position of responsibility in the telegraphic service, the first requirement should be a fair general education. Plain and legible penmanship should be required always, and no one who cannot write plainly—not necessarily elegantly—should be allowed to receive telegraph messages for delivery." A good moral character: that is, a character that would be esteemed upright and honorable by the general public, is also required. No situation can be held long where reliance cannot be placed upon the operator, and telegraphy is more exacting than most any other business or calling. Physical qualifications are also necessary; the general health must be good, the hearing and sight without fault, the hands capable of quick action, steady nerves, self-confidence, a good memory, and some degree of precision and rapidity in natural movements. The mastery of rules and forms, skill in reading from poor manuscript, and much general knowledge of business, names, customs, geography, etc.

The ability to transmit correctly at a rapid rate with one hand, while timing with the other the messages sent, skill in adjusting instruments to every variation in the current, particularly in bad weather or on a faulty line.—"In sending, the exercise of judgment in gauging the writing to the ability of the receiver, and the peculiar telegraphic sense to instantly detect an error, even in a cipher message, to never break except when in doubt as to the correctness of a word, and then *always* break. The exercise of good manners on the line, and to be always on time, and diligent." Besides this, "every telegraph operator should make it his business to acquire a knowledge of the elementary principles of electrical science, upon which the telegraphic art is based. There are certain elementary principles of electrical science which are intimately associated with telegraphy, a knowledge of which should be acquired by all who aspire to recognition and position as telegraphers; these are the conductivity and resistance of wires, instruments, batteries, etc., and a general knowledge of connections of batteries, instruments, and lines, so as to be able to make the necessary connections intelligently."

It is to be regretted that up to the present time there has been in telegraphy no really recognized standard of efficiency or proper classification of positions, although it would seem to systematize and regulate the classification of operators, positions, compensation, and promotion, would prove advantageous to both employers and employed as well as the general public.

Most operators commence their career upon railroad lines, or in a branch office in a city, and more fail in the first attempt from *lack of confidence*, and from not comprehending the responsibilities and duties, than from incapacity to telegraph. The young operator should understand what his office hours are, and never be absent in them. If called upon for extra service, be careful not to leave till dismissed by the officer in charge.

Never allow a message to remain undelivered in the office, or a message to hang unsent on the hooks.

Handle all business accurately, but especially train messages, which involve life and property. Never deliver a train order till it has been repeated to the train dispatcher, and he has sent the "all right" in reply.

Never assume the responsibility of another without instructions to do so.

Be pleasant and polite to all with whom you have business, on the line and in the office.

It is easy to learn and to keep the reputation of being prompt and efficient.

The first situation is sometimes difficult to secure, but once employed, a good operator is seldom out of work. Keep your office, books, and papers neat and in order. Enter your business daily, and make all reports to the railroad and telegraph company when required.

Telegraphing is the road to many excellent situations in railroad, express, and business circles.

SECTION X.

SCIENCE IN TELEGRAPHY.

ELECTRICAL ENGINEERING.

As the results of observation and study of *electric science*, the electric telegraph has its origin. Yet it is not to be expected that even a considerable portion of those engaged in practical telegraphy should be expert electricians, but it is desirable that they should acquire and learn the rudiments at least of the science upon which their profession is based. However, overcrowded the lower walks of the profession may become, there is *always* a deficiency in the number of those who are properly

qualified to fill the higher positions of honor in the telegraphic service, as circuit managers and the positions which require something more than the ability which is popularly supposed to suffice as mere mechanical manipulators and readers of telegraphic signals.

"That there is a general sentiment among telegraphers that only a superfical knowledge of the art is necessary, is well known. They aspire to nothing more in this direction than will suffice to enable them to transmit and receive messages, and draw such salary as may be accorded to them by their employers for their services. Anything beyond this they consider superfluous, and many rather pride themselves than otherwise upon the paucity of their acquirements. They regard any attempt to teach them more as absurd and undesirable, and are disposed to sneer at their fellows, who, with ambitious appreciation of what is required to become really proficient in their business, seek to acquire the knowledge which will qualify them for the proper and intelligent discharge of their duties."

New adaptations of the telegraph to popular service are constantly being made; the progress of electrical invention is one demanded by the age, and is rapidly being developed. It is from the intelligent and ambitious class of employes that the offices of honor and profit in the telegraphic service of the future must mainly be filled; besides this the rapid development of electrical science is creating a great demand for skilled electricians in other fields. Electrical engineering may now be properly termed as one of the important professions of the age. The late electrical exhibition in Paris has revealed the marvelous results already attained by science, and its practical applications are already established in the system of cables, electrical railways, electric lights, the telephone, and other recent inventions of electrical appliances, and yet the possibilities of electricity are believed to be but slightly invaded. What the future may witness in electrical development, it is impossible to foresee.

The time, it would seem, will ultimately come when steam and horse railways and postal communication shall be entirely superseded by electrical appliances for traveling, and for all manner of correspondence. In view of these considerations it should be the aim of every ambitious operator to become thoroughly conversant with the elementary principles and the applications thereof of electrical science, especially that which is intimately associated with telegraphy. "In order to obtain any considerable proficiency in electrical studies, a thorough acquaintance with arithmetic, especially decimals, percentage, and evolution, and algebra, at least as far as quadratics, is almost indispensable. The latter study is now taught in nearly all the public schools, and so much of it as is necessary for ordinary purposes may be acquired with very little difficulty. It is a most invaluable aid in scientific calculations, and indeed without some knowledge of it, most of the text-books will be found of little use to the student."

After becoming *thoroughly familiar* with the subject matter treated of in *this work*, for more complete text-books on the special subject of electricity, and the many branches of telegraphic and electrical science and engineering, we recommend the following: Prof. Tyndall's *Lessons in Electricity;* "Jenkins' *Electricity and Magnetism;* Preese and Sivewright's *Telegraphy;* Prescott's *Electricity and the Electric Telegraph*, and Sprague's *Electricity; Theory, Sources, and Applications;* which may be taken up advantageously about in the order named. Preese and Sivewright's work is English, and of course much that is said about special telegraphic systems is inapplicable here, but general principles are well explained. Prescott's work is very complete, covering the whole subject to the present time, and will be of the utmost service, especially to those who are tolerably familiar with the general subject. *Sprague's* and *Jenkins'* works should be as thoroughly mastered as possible. They are both excellent works, and may be profitably studied by all telegraphers."

However, "to become a good electrician, in the ordinary acceptation of the term, requires deeper study and application. The works above mentioned would be good ones to commence with, and when these are mastered, others more abstruse will be naturally suggested to the student. Personal investigation and experiment will supplement the instruction derived from books. In electrical science there is always plenty of new discoveries to be made to maintain the interest of the student and investigator. There is always something new to be learned; and this, to the industrious and studious mind, makes it a very fascinating and absorbing subject. Operators should, however, carefully distinguish in their minds between what is requisite to become a good, capable telegrapher and the more abstruse scientific education which is necessary to become a good electrician."

Those who become *adepts* in electrical science, must devote years of earnest study thereto, and it is not to be expected that the number of such will ever become very large. But this field would seem by the nature of things, to properly belong—by first right, to the practical telegrapher, who is sufficiently ambitious and energetic to embrace the opportunity.

PART SECOND.

ELECTRICITY.

"Electricity can have no rival. Steam may be superseded, but electricity is the great natural agent, and all inventions and improvements can only increase its usefulness and its applications. As a means of communication at a distance, it must ever remain the most wonderful and the most satisfactory."

SECTION XI.

ELECTRICITY IN GENERAL.

To what does the telegraph chiefly owe its efficiency?—To a natural agent called electricity, a name derived from the Greek word signifying *amber*, the body on which it was first observed, when rubbed upon fur, wool, or silk, acquiring the property of attracting light objects.

What can you say of this agent?—Its character is not well understood. Whatever it may be, it is supposed to pervade all nature. Until quite recently it was considered a subtile fluid, but at the present day eminent physicists regard it not as a fluid, but as a dual, polar *force* or *energy*.

We speak of the flow of the electric current for convenience, but as a matter of fact there is no such thing properly speaking as a flow of electricity. The electric current is the result of disturbed electrical equilibrium, and the direction

of motion in this case is as much one way as the other. The student must not be misled, therefore, by the employment of terms which seem to recognize the existence of electrical fluids, as such terms have lost their significance, and are used merely as conveniences, until the nature of electrical *force* can be more fully developed and a consistent nomenclature adopted.

When was this force discovered?—The force of electricity was known 600 years before Christ, but no advance was made in the science for 1,600 years.

What is known of this force?—Simply that an effect travels with inconceivable rapidity and seemingly in both directions—and always exists in two forms opposite to each other, called positive and negative, and is supposed to be nearly related to heat, and transmitted *like heat*, in a metallic bar, which is hot at one end, and cold at the other.

What are the properties of electricity?—In its natural, unexcited state, electricity does not exhibit its properties, because in that state it makes no manifestations of itself whatever.

(Unless, indeed, the universal phenomena of attraction and repulsion in their various forms be regarded as springing from this all pervading agent.)

When excited, it possesses the power of attraction and repulsion.

In motion through living animal bodies, it occasions a contraction of muscles, accompanied by a peculiar sensation.

Under certain circumstances it emits light, and causes perceptible changes of temperature.

Some, however, maintain that the light it exhibits is caused by the agitation which it produces in the air, and that hence the emission of light is not a property of electricity.

It resembles heat in having no weight; but differs from it in not producing expansion in material substances.

It also has a powerful effect in exciting chemical action.

How is electricity developed?—Chiefly in two ways: by friction and by chemical action. It is also developed by several methods

of induction and by heat, by magnetism, and by compression, and, in fact, by almost every motion which occurs upon the face of the earth. Electricity neither increases nor diminishes the weight of bodies under its influence ; neither does it affect their bulk.

What two kinds of opposite electricity are there?—Vitreous or positive, and resinous or negative. In a natural state, these two kinds always seem to be intermingled, thus neutralizing each other.

It must be understood at the outset that the electricities termed respectively positive and negative, do not sustain to each other the relation implied in those terms. That which is denominated negative is a positive or actual power as really as the other. "The phenomena of positive and negative electricity may be rudely illustrated by those of elasticity as exhibited by an ordinary spring. Let the spring in its unstretched state represent a body in its unelectrified condition, in which case it manifests none of the peculiar power which it possesses. It is impossible to stretch the spring from one extremity only; but if fixed at one end, a weight being attached to the other end, it will seem to be stretched by one force only. In reality, however, this is not the case, as may be shown by substituting a weight for the fixed point to which the spring is attached, equal in amount to the weight attached to the other end of the spring. The strain upon the spring remains unaltered, but a reaction equal in amount to the action of the original weight, is instantly rendered evident. So it is with electricity. It is sometimes the case that but one kind of electricity seems to be present; but a careful examination will always reveal an equal amount of the opposite kind."

What is the algebraic sign applied to positive and negative electricity?—The sign + for positive, and — for negative.

State the law of electrical attraction and repulsion.—Like kinds repel and unlike kinds attract each other.

What is the effect of separating the opposite kinds of electricity?—It destroys the electrical balance or equilibrium; and the separated electricities constantly attract each other, and tend to unite again.

When is a body said to be electrically excited or electrified?—When its positive and negative electricities are separated from each other.

In causing this separation no new electricity is or can be produced.

How is electricity otherwise divided?—Into six kinds.

1st. Frictional or static.
2d. Chemical, galvanic, or voltaic.
3d. Magneto-electricity, or magnetism.
4th. Thermo-electricity.
5th. Atmospheric electricity.
6th. Animal electricity.

In what respects do these several kinds differ?—They are supposed to differ, not primarily in their nature, but in their manifestations or modes of action only.

How is electricity manifested?—In its effects solely; and these are seen only when it is excited, that is, when it moves or tends to move. It may be excited in all substances, may be communicated from one electrified or excited body to another previously in a neutral or unelectrified condition, and it may be stored up, in certain instances for practical, as well as for experimental purposes.

What general principle may be observed in regard to the direction of electricity in motion?—The positive and negative elements always seem to move simultaneously, and in opposite directions.

At what rate does it move?—Its rate varies in different conductors, and according to circumstances, but in the best it approaches or perhaps exceeds the speed of light, viz., 192,000 miles per second. The first signal is felt in the Atlantic cable in four-tenths of a second, but the following ones go through more rapidly.

SECTION XII.

FRICTIONAL ELECTRICITY.

What is frictional electricity?—It is that form of electricity which is generated by friction.

Upon what substances is it excited?—Upon non-conductors; generally upon glass or sealing wax.

May not electricity be excited by friction upon the surface of conductors?—It may; but in that case it is instantly conducted away, and hence cannot be accumulated.

What is the office of friction in exciting electricity?—It is simply to separate mechanically or otherwise, the positive and negative elements previously existing in the substances employed.

Mention a simple experiment illustrative of frictional electricity.—If a piece of dry glass, amber, or sealing wax be briskly rubbed with woolen cloth, it will exhibit electrical effects. Small fragments of paper, cotton, or other light substances, will be attracted to the excited surface, charged with electricity and then repelled.

The experiment may easily be so varied as to illustrate many of the properties of the agent in question.

What instrument may be employed to show the presence and character af electricity?—The electroscope.

What is an electroscope?—There are several forms. The following may be readily made or procured by the student:

The Pendulum Electroscope consists of a small ball of dry elder pith, which is suspended from a support by a fine silk thread, in such a manner that it is perfectly free to move in any direction. A glass rod, supported by a base of dry wood and bent at right angles at the top is probably the best support.

The Gold-Leaf Electroscope consists of two narrow strips of gold-leaf, suspended in a glass jar from a metallic rod, which passes through the wooden stopper of the jar, and is terminated with a metallic ball. The jar is open at the bottom and is cemented to a metellic base, from which two strips of tin-foil extend to points opposite the gold leaves. If an electrified body be brought near the ball, the gold leaves separate, or, if previously separated, collapse, or separate more, according to circumstances. Two silk ribbons may also be used as an electroscope.

With the electroscope many experiments may be performed, showing the fundamental phenomena and character of electricity as developed by friction.

What apparatus is employed in generating electricity for large experiments?—The electrical machine, and the electro-static induction coils of Ritchie and Ruhmkorff, producing powerful electro-static effects, and great electro-motive force, by induction, from a battery of small electro-motive force.

What contrivance is employed for retaining charges of electricity?—The Leyden jar, so called from the name of the place where invented.

What properties of electricity may be exhibited by experiments with these apparatus and battery?—Its power of attraction and repulsion, induction and emission of sparks and light, its varied capacity for transmission over different substances, its power to give shocks, etc., etc.

SECTION XIII.

CONDUCTORS, INSULATORS, INDUCTION.

When is a body said to conduct electricity?—When an electrical discharge passes over or through it.

"According to the views of the great mass of eminent electricians, both in Europe and America, conduction of electricity of whatever name is *through* the mass of the conductor and not by surface action such as is exhibited in the statical condition of electricity."

Do all bodies possess equal conducting power?—No, the conducting power of different substances varies in almost every possible degree, from the highest to the very lowest.

Are there any substances which will not conduct at all?—Probably not.

Explain the terms conductor and non-conductor.—Those bodies are commonly called conductors which conduct readily, and those non-conductors which conduct slowly; though strictly speaking, all bodies are conductors, and there are no non-conductors.

Name the most common and best conductors.—Metals, water, charcoal, and animal bodies; but these differ much among themselves. Of metals, silver, copper, and gold are the best; the two former conducting about five times as well as iron or platinum.

Mention the most common non-conductors.—Glass, sulphur, resin, ice, silk, dry air, dry wood, varnish, porcelain, etc.

Any of these substances, however, will conduct electricity under certain conditions, or when covered with moisture, (or reduced to a powder), though, in that case, it is strictly the moisture that conducts, rather than the non conducting substance.

What is insulation?—The separation of a body from surrounding objects in such a manner that it can neither receive nor impart electricity.

How is a body insulated?—By being supported and surrounded by non-conductors.

What is the most common insulator?—The atmospheric air.

What is induction?—It is the power which an electrified body has to develop electricity in a body not electrified, when the bodies in question are brought near together, but not sufficiently near for electricity to pass from one to the other.

How is induction accomplished?—By the power of attraction and repulsion, separating the electricities of the unexcited body according to the universal law, viz., *likes repel and unlikes attract each other.*

Professor Faraday's theory of induction conceives electrical induction to depend on a physical action between contiguous particles, which does not take place at a distance without operating through the particles of intervening non-conductors. A separation of the opposite electrical forces takes place in these intermediate particles, and they become disposed in an alternate series of positive and negative poles; this he termed a polarization of the particles, and in this way he supposed, a force to be transferred to a distance. He also assumed that *all material particles* are conductors to a greater or less extent; that in their unexcited state they are not arranged in a polarized form, but become so arranged by the influence of charged particles, in their immediate vicinity, when they assume a forced state, and tend to return by a powerful tension to their original position ; that being *more* or *less* conductors the particles become charged either *bodily* or by *polarity;* and that contiguous particles can communicate their influence more or less readily. When less readily, the polarized state is enhanced, and a more or less perfect *insulation* results; when more readily, *conduction* takes place.

What takes place when the bodies causing and receiving induction are removed from each other's influence?—The latter usually returns to its original, unexcited state. If, however, it be uninsulated before induction takes place, but insulated during the continuance of the same, it will remain electrified even after the source of induction is removed.

SECTION XIV.

TECHNICAL TERMS—ELECTRICAL UNITS.

What is the meaning of the term "circuit"?—The wires, instruments, etc., forming the path for the passage of the current.

What is meant by "derived circuit"?—When part of a circuit is divided into several parallel branches, each is called a derived circuit.

What is the meaning of "metallic circuit"?—A circuit in which a return wire is used instead of the earth—as when two wires are looped.

What is the meaning of the term "current"?—The supposed passage of electricity, or transfer of electrical force, not as a fluid or gas, but progressive in its nature, like the passage of light through space, or of heat through a bar of metal.

What is the meaning of the term "potential"?—A term used to indicate a condition for, or tendency to do work, and is applied to electricity in the same way that the word pressure is used with reference to a fluid.

What is meant by difference of potential?—Difference of potential is a difference of electrical condition in virtue of which work is done by positive electricity in moving from the point at a higher potential to that at a lower potential, and it is measured by the amount of work done by the unit quantity of positive electricity when thus transferred. The idea of potential essentially involves a relative condition of two points, so that no one point or body can be said to have an absolute potential. *The potential* of a body is the difference of its potential from that of the earth, which is assumed to be at zero. Difference of potential for electricity is analogous to difference of level for water. —*Jenkins.*

What is the meaning of "electro-motive force"?—The force which develops electric tension or potential, energy, the power of overcoming resistance, and is to the current what pressure is to steam.

The words *electro-motive force and difference of potential* are used frequently one for the other, but they are not strictly speaking identical. Electro-motive force is the more general term of the two, and includes difference of potential as one of its forms.—*Jenkins.*

What is meant by "resistance"?—The opposition presented by the circuit to the passage of the current, and is the opposite of its conducting power, and the property of every substance, varying only in degree, however the obstruction and facility to the passage of the current through a circuit are similiarly applied by the term resistance.

What is meant by joint resistance?—The resistances of two or more circuits considered as one.

UNITS OF ELECTRICAL MEASUREMENT.

In order to measure anything we must first provide ourselves with suitable known standards or units of measurement, with which the unknown quantities may be compared. Thus, in measure of space, we have the inch; in measure of time the second; and in measure of force or weight, the pound.

What is an ohm?—The unit of resistance, also called the B, A unit.

How did the name originate?—So called in honor of Dr. G. S. Ohm, a distinguished German mathematician, of Nuremberg, Germany, who was the first to discover and lay down the true laws of electrical action.

What is the resistance represented by an ohm?—It is equal to the resistance of a round wire of pure copper sixty-five one thousandths of an inch in diameter, and 408 feet 4 inches in length, at a temperature of 60° Fahrenheit. This is the size generally known as No. 16 wire, Birmingham gauge, ordinary of-

fice wire. Roughly it is equivalent to the resistance of 330 feet of ordinary No. 9 galvanized wire, such as that used in the construction of telegraph lines. It will therefore be understood that the *ohm* is a unit of resistance in the same manner that an inch is a unit of length, or a pound a unit of weight.

What may be stated as the essential properties of an electric circuit?—The essential properties of an electric circuit may be said to be, first, the electro-motive force included or contained in it; second, its resistance to the passage of the current; and third, the magnitude of the current so passing. When any two of these three properties have a known value, the value of the third may readily be ascertained.

How may the third be ascertained, when any two have a known value?—This is done by means of *Ohm's law*, upon which all electrical measurements are founded—the importance of which is only equalled by its simplicity

The following statement and demonstration of *Ohm's law* is from an article on the "Elementary Principles of Electrical Measurement," written by Mr. F. L. Pope, and published originally in *The Telegrapher*. He says: From the fact that Ohm's law is expressed in most books by algebraic formulæ, students are apt to be very much afraid of it, but there need really be no difficulty in understanding it. Unless he does understand it, the student can make but little progress towards a thorough knowledge of the phenomena of the electric current.

What is Ohm's law?

1. The current in any circuit is found by dividing its electromotive force by its resistance.

2. The resistance in any circuit is found by dividing its electro-motive force by its current.

3. The electro-motive force in any circuit is found by multiplying its resistance by its current.

4. The quantity of electricity produced in any circuit is found by multiplying the current by the time during which it flows.

How is Ohm's law expressed by algebraic formulæ?—The algebraic formulæ are nothing more than a *short way* of writing down the same answer as above, thus:

Let Q denote the total quantity of electricity generated in any circuit.

Let E denote the electro-motive force in the circuit.

Let R denote its resistance.

Let C denote the current flowing in the circuit.

Let T denote the time during which the current flows.

We may then write down the above statements, thus:

$$(1)\ C = \frac{E}{R}. \qquad (2)\ R = \frac{E}{C}.$$

$$(3)\ E = R\,C. \qquad (4)\ Q = C\,T.$$

For the benefit of those who are not familiar with algebraic formulæ it may be well to state that, when two letters standing for numerical quantities are placed one above another in the form of a common fraction, it signifies that the quantity above the line is to be divided by the quantity below the line.

Thus $\frac{E}{R}$ signifies E divided by R.

The sign = denotes *equality;* or that the quantities on one side of the sign are equal to those on the other side.

When two or more letters standing for numerical quantities are written together, one after the other, it signifies that they are to be multiplied together. Thus in the above case, the expression E = R C means that E is equal to the products of R multiplied by C, or in other words that the electro-motive force (E) is equal to the resistance (R) multiplied by the strength of current (C) which is exactly what was stated above in the third paragraph of Ohm's law—only in the former case it required 78 letters to explain it, and in the latter we can express precisely

the same thing by means of four letters and one arbitrary sign, which perhaps may serve to give the student some idea of the reason why persons who understand algebra prefer to use it whenever circumstances permit.

What is the resistance represented by an ohm according to the British Association standard?—It is equal to the resistance of a prism of pure mercury, 1 square millimeter section and 1.0486 metres long, at 32° Fahr.

What is Siemens' unit of resistance?—The ohm and Siemens' resistance units do not differ greatly from each other. According to the most trustworthy determination 1 ohm is equal to 1.0486 Siemens' units, and one Siemens' unit is equal to .9536 ohms. The Siemens' unit constructed in 1860 by Dr. Werner Siemens, of Berlin, Prussia, is defined as being equal to the resistance of a column of chemically pure mercury, one metre in length and one square millimetre in sectional area, maintained at a temperature of 0° Centigrade or 32° Fahrenheit.

What is a volt?—The volt, so named from the Italian philosopher, Volta, the discoverer of the voltaic battery, is the unit of electro-motive force of a single Daniell, or sulphate of copper cell, and for many purposes may be considered equivalent to it. According to Mr. Farmer's determination, the sulphate of copper battery used in telegraph work has an electro-motive force equal to 0.93 or 93-100 of a volt. Therefore, the ordinary Daniell cell furnishes a unit of electro-motive force of sufficient uniformity and constancy for ordinary purposes, and one which is used in this way very generally by practical electricians. Sir William Thomson says no human being can stand an electro-motive force equal to 250 volts.

What is the farad?—The farad, so called in honor of the English philosopher, Michael Faraday, distinguished for his researches and discoveries in electrical science, is the unit of quantity and of electro-static capacity. It is equal to the quan-

tity of electricity that will pass through a circuit having a resistance of 1 ohm during one second, with an electro-motive force of 1 volt, and is as necessary as a unit of resistance, or electro-motive force. The farad is used in determining the amount of charge a condenser is capable of.

Is there a unit of conductivity?—There is no unit of conductivity. Conductivity is the reciprocal of resistance.

What is the weber?—The weber, so named from a German philosopher of that name, is the unit of current. Jenkins, who is probably the best authority on the subject, gives one farad per second as the unit of current.

What are the names and values applied to the multiples and sub-multiples of electrical units?

The megavolt, one million volts.
" megafarad, " " farads.
" megohm " " ohms.
Similarly:
The microvolt, one-millionth of a volt.
" microfarad " " farad.
" Microhm, " " an ohm.

—*Jenkins.*

What are the units of electrical measurement adopted by the International Electrical Congress held in Paris in 1882? The International Electrical Congress held in Paris decided to make use of the centimeter, gramme, and second in all electrical measurements. They will retain the practical units, ohm for resistance, and "volt" for electro-motive force. The *intensity* of a current produced by one volt, with a resistance of one ohm, will be called one "ampere;" and the quantity of electricity given by one ampere in one second will be called a "coulomb;" the term "farad" indicates the capacity of the condenser which, laden with a volt, holds one coulomb of electricity. The old

term "weber," as a unit of intensity of current, will not be used.

SECTION XV.

VOLTAIC ELECTRICITY AND THE MEANS OF EXCITING IT.

As the results of observation and study, between 1780 and 1793, *Galvani*, professor of anatomy in the University of Bologna, discovered that convulsive movements might be produced in the legs of a frog recently killed, if brought into contact with two dissimilar metals [*e. g.* zinc and copper] which are themselves in conjunction. This discovery, seemingly insignificant, formed the foundation upon which to rest the splendid superstructure of volta-electrical science, together with its various practical applications. *Volta*, of Pavia, a pupil of *Galvani*, became interested in his master's discovery, and devoted himself to experimental research, which resulted in the invention of the *voltaic pile*. From this it will be seen that the term *galvanic battery* is a misnomer, for *Galvani* had nothing to do with its invention; indeed it was not devised until after his death.

From these simple foundations have sprung all other forms of galvanic or voltaic batteries, and the force which is generated by these batteries is termed voltaic electricity.

What kind of electricity is employed in the telegraph?—Voltaic, chemical, or galvanic electricity.

What is voltaic electricity?—That branch of electric science which treats of the electric currents being developed by chemical action. Especially from that attending the dissolution of metals.

How does voltaic differ from frictional electricity?—Voltaic electricity discharges itself steadily, while, frictional, on the other hand, acts abruptly and instantaneously.

This difference results, undoubtedly, from the manner in which art excites the agents in question, and not from any inherent peculiarity possessed by them. It is the steady movement of the voltaic current that adapts it to the purposes of the telegraph.

What must be the arrangement of the conductors upon which voltaic electricity moves?—They must be arranged in an unbroken series called a circuit.

What contrivance is employed in developing voltaic electricity?— The voltaic cell, or battery.

There are many forms of battery, but we shall here be able to consider only two, viz: the most simple form, commonly called the simple voltaic circuit, and the form generally employed in main and local telegraph offices. The explanation of these, however, will embrace all the fundamental principles of other forms.

What are the essential parts of a voltaic battery?—Two dissimilar conductors and a liquid. These must be so related that the liquid will act chemically upon at least one of the conductors, and that if it acts upon both, it will affect them differently,

A battery may be formed by a combination of two dissimilar liquids with one solid conductor.

What conductors are commonly employed?—Metals, and among them copper, platinum and zinc most frequently. Recently, solidified carbon also is largely employed.

State the composition of zinc.—Ordinary zinc contains carbon, lead, and iron, the latter partly derived from the melting pots when not lined with fire-clay, as they always should be.

How is the electric force produced?—The electric force is produced by the waste of one of the metals, and neither this nor any other force can be produced without the consumption or waste of something or another, otherwise we should at once have discovered perpetual motion, and there would be no necessity for mainsprings for watches nor of coals for steam engines, and so on.

A battery produces electricity by the combustion of zinc as a fire produces heat by the combustion of coal. To obtain heat from coal, however, it is only necessary to light it in the presence of air, whereas to obtain electricity from zinc a

special combination of that metal with another metal or conductor, and a liquid is required. The liquid must be one which has a strong chemical affinity or attraction for zinc.

What liquids are employed?—Water, with sulphuric or nitric acid.

State the chemical constitution of these substances.—Water is composed of one equivalent of oxygen and two of hydrogen.

Sulphuric acid is composed of three equivalents of oxygen and one of sulphur.

Nitric acid contains five equivalents of oxygen and one of nitrogen.

Sulphuric acid is always combined with one equivalent of water.

How may a simple voltaic circuit be formed?—By placing in a vessel of water mingled with a little sulphuric acid, a slip of copper and another of zinc, and making a conducting connection between them.

How may this connection be made?—By bringing the metals into contact, or by passing a wire or other conductor from one metal to the other. The latter is the usual method.

Why is this connection between the metals necessary?—Because without it there is no action.

What substances are affected in the primary action of such a circuit?—The zinc and water only are affected.

Explain the chemical actions of the battery.—As soon as the metals are connected, the water begins to be decomposed, and the zinc dissolved particle by particle. The zinc unites with the oxygen of the water, forming oxide of zinc, and the hydrogen is set free and escapes.

What is the electrical effect of this process?—When chemical action begins, the positive and negative electricities are separated at the surface of the zinc, and pass, one to each metal. From the latter, they proceed in opposite directions over the con-

ductor between the metals, until they reach the starting point, viz., the zinc surface, when they unite again. This process is incessantly repeated until the chemical forces of the battery are exhausted. Thus there are two currents of electricity constantly acting in opposite directions.

The electrical forces are here spoken of as being separated and united at the surface of the zinc. In reality, however, this process occurs in every particle throughout the circuit. Still the above language may be regarded as sufficiently exact in view of the two considerations following:

1st. Though electrical action takes place in every part of the circuit, yet it is developed or originated in the particles at the zinc surface, while other particles throughout the circuit simply transmit it. The former are active, the latter passive. The former might be called motive, the latter transmissent particles.

2d. The expression "a current of electricity" denotes properly the passage, not of matter or substance, but of force or motion.

What is the direction of the current?—Although there are two electric currents passing simultaneously in opposite directions, it has been agreed to call the direction in which the *positive* electricity moves the direction of the current. However, the direction of a voltaic current, in any particular instance, depends entirely upon the nature of the chemical action which produces it.

If contact be made between a piece of pure zinc and a piece of copper, the whole being immersed in dilute of sulphuric acid, the course of the current within the liquid will be from the zinc to the copper; if strong ammonia water be substituted for the dilute acid, however, the course of the current will be reversed.

What then is the office of the conductor between the metals in this and every form of battery?—It is simply to furnish the separated electricities a channel by which they may unite again; or in other words, to restore the electrical equilibrium which the chemical action of the battery has destroyed.

State the electrical relations of the metals of the circuit.—Copper as compared with zinc is electro-negative and hence attracts the positive current. Zinc acts in an opposite manner. The name of the poles or wires leading from the battery is the oppo-

site of that of the metals in the battery they lead from. Thus the zinc is the positive metal or element of the battery.

Positive electricity is developed upon the surface of the *more oxidizable metal which is acted upon* by the exciting liquid, which is termed, for that reason, the *electro-positive*, or more simply, the *positive* metal. If this be true, *negative* electricity must proceed from the opposite plate, that is, the one upon which the liquid exerts no action, and, consequently that plate is termed the *electro-negative* or *negative* metal. In fact, it is possible to classify all of the elements upon this principle, into electro-positive and electro-negative substances. In other words, the various elements, when opposed to each other under certain circumstances, assume a *polarized condition*. This being the case it is easy to account for the fact that the portion of metal which is *outside* of the liquid constitutes a pole of the battery, opposite in name to that of the plate itself.

What then may be considered the universal rule?—That metal which is affected by the primary action of the battery is electro-positive within the liquid, and hence affords a negative current.

Which current, then, does each metal furnish to that part of the circuit which is exterior to the liquid?—Copper yields a positive and zinc a negative current. The former is, therefore, called the positive and the latter the negative pole of the circuit or battery.

What general principle holds true in regard to the poles of every voltaic battery?—That metal which is electro-negative attracts the positive current in the liquid and hence is termed the positive pole, and vice versa.

May several cells like the one just described be united in one battery?—They may; and the effect thereby is greatly increased.

What principle must be universally observed in making battery connections for telegraphic purposes?—Positive poles must connect with negative, and negative with positive.

Why might not a battery of simple circuit, of this description, be employed on telegraphic lines?—For two reasons.

1st. The zinc surface is quickly coated with the oxide formed by its combination with oxygen.

2d. The liberated hydrogen adheres in bubbles to the copper plate preventing, in a great degree, its contact with the water.

By these causes, the action of the circuit is speedily interrupted.

What should be the principal qualities of batteries adapted for telegraph purposes?—Telegraph batteries being destined to operate upon circuits, which are generally of great resistance, should combine as many as possible of the following qualities, and each should be as fully developed as possible.

1. Great electro-motive force.
2. Constancy.
3. Be easy to clean and charge.
4. The charge should be of long duration.
5. Feeble interior resistance.
6. Durability.
7. Simplicity of construction.
8. Low in price.
9. Not expensive to maintain.

Perhaps among all of these, No. 5, a feeble interior resistance, is to be most insisted upon, for it is well known that upon telegraph lines the effect of derivations is as much greater as the interior resistance. The first cost, No. 8, is of little moment, compared with No. 9, or the cost of maintenance—which includes the cost of materials for charging and attendant's salary.

The conditions above catalogued, it will be seen, are numerous and difficult to combine, and as might therefore be anticipated, the number of batteries adapted for telegraphic purposes is very limited.—From *La Lumere Electrique.*

THE CALLAUD OR GRAVITY BATTERY.

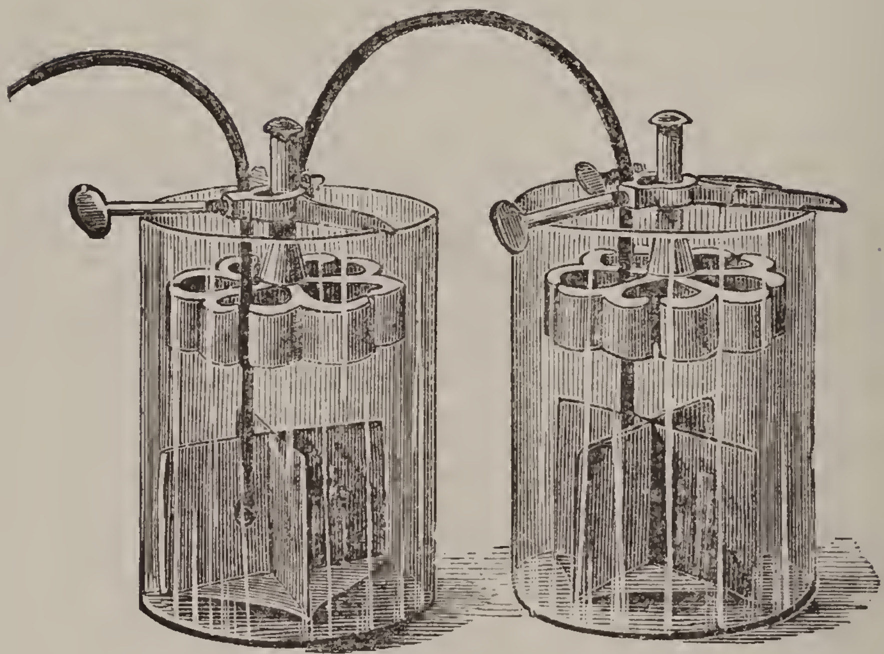


Fig. 3.

What battery is employed for telegraphic purposes?—The gravity constant battery is the adopted standard form in general use throughout the United States, upon both main and local circuits. See Fig. 3.

What is said in general of its construction?—It is formed upon the same principle as the simple voltaic circuit already described. It is more complicated, however, being designed to produce a constant and steady current.

In what respect does it differ from the simple voltaic circuit?—Chiefly in two respects, viz:

1st. The copper and zinc are separated. The zinc suspended near the top and the coper placed in the bottom of the jar.

2d. The sulphuric acid is supplied not in its own proper form, but in combination with oxygen and copper in the form of blue vitriol, or sulphate of copper.

Of what is blue vitriol composed?—Of sulphuric acid and oxide of copper.

What is oxide of copper?—It is a compound of oxygen and copper.

What metals are employed in the gravity battery?—A scroll form of sheet copper, and a solid wheel of zinc.

What liquid?—Water saturated with blue vitriol.

Explain the arrangement of this battery.—It consists of a glass jar about seven or eight inches high, nearly filled with soft water, immersed in which, at the bottom, is the scroll form sheet of copper having fastened to it an insulating conducting wire, which, passing through the liquid up the side, and out at the top of the jar, constitutes what is termed the copper or positive pole of the battery; around and on the copper in the bottom of the jar is placed about one half pound of sulphate of copper (blue vitriol); suspended above by means of a brass tripod or hanger (as it is called) is the wheel of zinc, which should remain beneath the surface of the liquid in the jar about two or three inches above the copper. The brass hanger is made to serve as a conductor from the zinc by means of a connecting post and screw, and thus constitutes the negative pole of the battery.

There are various methods in practice of putting up and maintaining the gravity battery. The plan most generally adopted is to fill the jar with sulphate of copper to the top of the copper frame, and with water to within an inch and a half of the top of the jar. Rain water should be used whenever it can be obtained, as hard water, or water containing lime or other substances in solution, impairs the strength of the battery.

Is there any other form of gravity battery?—Yes. The *crow-foot battery.* So called from the shape of the zinc. This form has been adopted by the Western Union Telegraph Company, and gives general satisfaction as a thorough, efficient substitute for every known form of blue vitriol battery in use for telegraphic purposes.

Why is it preferred to all others?—On account of its simplicity and cheapness, consisting as it does practically of but three parts, the "*jar*," "*zinc*," and "*copper*." The zinc being made heavier, and in such a shape that it is suspended by being hooked on the side of the jar. The *zinc in this battery*, however, *cannot be raised or lowered.*

Does the battery begin to act its full strength when first set up?—No. It does not.

What should be done to hasten its full action?—Put into the liquid four or five ounces of pulverized sulphate of zinc, then connect the copper with the zinc by fastening the wire from the copper into the screw post of the zinc or hanger, and leave it so for a few hours.

What is this called?—Putting the battery on a short circuit.

What does the strength of the battery depend upon?—Greatly on the position in which the zinc is placed in regard to the blue color.

How is the greatest effect obtained?—By lowering the zinc to within half an inch of the blue color, care being taken to allow no contact to be made between the two.

What should be done to render the battery more constant and lasting?—Raise the zinc farther above the blue color; this, however, decreases the power, but makes the battery more constant and lasting.

What can you say about the supply of blue vitriol?—The battery should be kept supplied with enough sulphate of copper, so that a blue color can always be seen in the liquid at the bottom of the jar, rising to within an inch of the lower surface of the zinc and not allowed to touch it.

What does it indicate if the blue color rise too high?—That too much sulphate of copper is being used, and no more should be put in until the blue color has receded almost to the bottom of the jar.

What does it indicate if the blue color recedes?—That more sulphate of copper is required.

What precaution should be observed?—Care should be taken that the battery circuit is not left open long enough to allow the blue solution to accumulate so as to attack the zinc, and that the latter is at all times submerged in the water.

Why does the liquid in the battery diminish in quantity?—It is caused by evaporation, and more water should be added from time to time to replace the loss.

Does the sulphate of zinc solution ever become too great?—It does.

What is the remedy?—Draw off a portion of the top of the solution with a battery syringe or cup, and replace it with clear water.

What is used to test the strength of the solution?—A hydrometer. When the specific gravity is less than 15 degrees there is too little sulphate of zinc; when it is 35 degrees or over, there is too much in the solution, and it must be diluted.

How should the battery be cleaned?—Once in two or three months it will be necessary to thoroughly clean the battery. Take out the zinc and copper carefully; pour the liquid into a separate jar, then throw away the dirt and loose copper in the bottom of the battery jar, and return the clean liquid which was in it before; set the copper back in its place, and add a few lumps of blue vitriol; scrape and wash the zinc thoroughly, and return also to its place. The battery should then be in good working order, and should not be disturbed unless to clean or to add blue vitriol.

Should the battery be allowed to freeze?—No, as the current would be very much impaired or altogether suspended.

Does the battery work more vigorously while warm?—Yes, as heat is a promoter of chemical action.

In the gravity battery what becomes of the zinc?—It is dissolved particle by particle and combines with the oxygen of the water, forming oxide of zinc.

What becomes of the oxide of zinc?—It remains in the water (though not without change) until it is removed by cleaning the battery. It darkens the water, and if allowed to accumulate, finally settles in a dirty mass to the bottom of the cell.

Some of it, at least, forms sulphate of zinc by uniting with the sulphuric acid after being liberated from the sulphate of copper.

Is the copper affected?—It is not affected by that action which produces the current, but gradually increases in size by the copper adhering to it which is liberated from the blue vitriol.

How is the blue vitriol acted upon?—It is decomposed; the sulphuric acid it contains is liberated in sufficient quantities to keep the battery in action, and its copper is set free and thrown down in fine particles.

In this battery why does the sulphate of copper solution occupy the lower and the sulphate of zinc solution the upper portion?—On account of the difference in their specific gravity.

Why does not hydrogen gas adhere to the copper cylinder and retard the action as in the simple circuit?—Because oxygen liberated from the oxide of copper in blue vitriol unites with it forming water.

What is the office of the sulphuric acid in the battery?—It is to excite chemical action among the other agents present, although it does not seem to enter into any of the process itself.

What about the connections?—They must be kept free from rust and dirt in order to allow the current to pass through them freely.

Why should not like poles be connected?—Because they would neutralize each other, and no current whatever be produced.

Is it necessary that the circuit of a voltaic battery be insulated? —It is only necessary that one half of it be insulated from the other half; or more exactly, there must be such insulation as will prevent all cross-communication between the different parts of the circuit.

May the earth be taken as a part of the circuit?—It may, provided the other parts be properly insulated from the earth.

What relation does the telegraph line sustain to the battery or batteries which work it?—It is simply a part of the conductor between the battery poles.

In the management of batteries what important principle must be constantly borne in mind?—That a current cannot be made to start from one pole of a battery, unless it can pass around and touch the other pole, be the distance a few inches or a thousand miles.

What is meant by the "internal resistance" of a battery?—The resistance offered by the liquids, and porous cell, if one is used, to separate the liquids.

What is usually the resistance of each cell of the gravity battery? —From 2 to 4 ohms, depending upon the size of the plates, their distance apart, and upon the degree of saturation of the sulphate of zinc solution.

The ordinary Callaud cell usually has about 3 ohms resistance. If such a cell were placed on "short circuit," that is, having its poles connected by a wire so thick as to offer no appreciable resistance, the current traversing the circuit would be equal to one-third of a farad per second. One-sixtieth of a farad per second is sufficient to operate the relays in the main circuit of a telegraph line. A local circuit for actuating a sounder or register usually has a current of from one-fourth to one-sixth of a farad per second.

What is meant by "polarization of the plates?—This term is applied to an action which occurs whenever the current passes from liquid to solid conductors; there forms on the surface of the latter a film different from the liquid, by which there is not only a greater resistance introduced, but an electro-motive force

is generated, opposing that of the current, so that if suddenly connected to a galvanometer, and the main circuit broken, a reverse current will be maintained for some time.—*Prescott.*

Is there any other form of battery used for telegraphic purposes? —Yes; various forms, the most common the Grove and carbon batteries for the main lines, and the Daniell for the local.

The construction and arrangement of these batteries is not explained, as they are not now in general use, having been superseded by the gravity battery.

What is meant by "earth batteries"?—That of operating an electro-magnet by means of a battery composed of plates of zinc and copper buried in moist earth, known for nearly forty years, the discovery having been originally made by Gauss in Germany, in 1838. It was re-invented by Alexander Bain, and patented by him in England, in 1840; and in 1844, Alfred Vail succeeded in operating Morse's original telegraph line from Washington to Baltimore, upon this plan.

"The disadvantage of the earth battery is that it is not possible by its means to obtain an electro-motive force above that of a single cell, because any number of pairs of plates that may be used, are in effect but one plate, for the reason that they are all virtually placed in a single cell. By thus burying large plates of zinc and copper in moist earth, a current may be obtained nearly equal to that of a Daniell element, which is sufficient to work an ordinary sounder with considerable strength. But on a line of any length, where there is resistance to be overcome, the effect would necessarily be very feeble. It is not strictly correct to say that electricity is generated by this process without the use of chemicals, as the action is really caused by the oxygen contained in the water of the moist earth uniting with and oxydizing the zinc, the action being in fact the same as when an acid is used, only it takes place much less rapidly. The comparative slowness of the action is more or less compensated by the increased size of the plates."

Has there any form of battery been perfected by which electricity may be stored for future use?—Yes, a storage battery has recently been invented by the eminent electrician of Cleveland, Ohio, Mr. Charles F. Brush, the inventor of the Brush electric light, who claims that his system is complete in every respect, and a commercial as well as a scientific success; that the loss of

energy in storing and in again giving up electricity is comparatively small, and that any required amount of electricity can be accumulated or stored, and afterwards used either for light, power, chemical action, telegraphy, or for any other purpose for which electricity obtained from other sources is used.

Explain in brief the "Brush storage battery."—"The Brush storage battery is simple in its construction, consisting of a square box containing cells, in each of which are two cast lead plates. The plates are electrically treated in a manner that is, of course, a secret, and are immersed in acidulated water. One of the plates is black, and is called the hydrogen plate, while the other is white, and is termed the oxygen plate. These plates are what are properly designated as the accumulators, and into them is stored the electricity. They are portable and can be packed and shipped as any other merchandise. They can be handled without danger, and can be made of any size required, so that there is no theoretical limit to the amount of electricity that can be stored. The capacity of a battery, of course, depends upon the number of cells it contains, and the size of the plates."

SECTION XVI.

MAGNETO-ELECTRICITY.

What is magneto-electricity?—That form of electricity which is generated by the relative movements of magnets and coils of wires, thus converting mechanical force into electricity.

How is magneto-electricity generated?—Electricity is generated for telegraphic and other purposes by means of magneto-electric machines, without the aid of chemical action. In this case we have a direct conversion of mechanical force into electricity

What is the magneto-electro machine?—They are made in many

different forms, but the best and most powerful machine consists of two parallel electro-magnets. A Siemens armature is placed at each end. They are, however, of different sizes. The smaller one is in circuit with the coils of the electro-magnet, and the larger one furnishes the working current. The two armatures are revolved simultaneously. The current is at first generated in the coils of the smaller armature by the residual magnetism of the electro-magnets. This armature, as it revolves, sends the currents generated in its coils through the coils of the magnet. The magnetism thus increased magnifies the currents induced in the revolving coils, and at the same time develops powerful currents in the larger armature, thus carrying on the principle of mutual accumulation. The current developed in the larger armature is utilized for the purpose desired.—*Lockwood's Notes and Queries on Electricity.*

What is the principal application of magneto-electricity?—Its application to the production of the electric light, to electroplating, to magneto bells as telephone signals, to the telephone itself, in which magneto currents may be said to be involuntarily generated by the human voice; and more recently its successful practical application to telegraphy, by dynamo-electric machines designed to supply a continuous current, adapted and in use by the Western Union Telegraph Company at the larger offices.

In the New York office of the Western Union Telegraph Company, the largest telegraphic office on this continent, at least 20,000 cells of gravity battery have already been supplanted by the use of the dynamo-electric machines, and the remainder are doomed to follow. There are 10 dynamo-electric machines, in constant use, day and night, and 5 spares are always ready to be used at a moment's notice. The 10 that are in use are divided into two gangs, of 5 each, and each gang is driven by a 10 horse-power steam engine. In each gang 4 of the machines are connected

in series, like cells in a battery, and the current from the fifth machine is used to energize the field magnets of the other four. One gang furnishes + electricity to line, and the other gang − electricity to line ; this being required on account of the varying polarities of the batteries at the distant ends of the lines. The spare gang is used when either of the other gangs is under repair or examination, the current being changed in direction by a switch, according to requirement.

A gang furnishes a current having about 350 volts E. M. F., or equivalent to about 350 cells of Callaud battery.

The undoubted economy resulting from the use of these machines for telegraphic purposes, aside from the small cost of maintenance, lies in the fact, that, owing to their very small internal resistance, an immense number of lines can be worked from one gang of generators. Of course, the lines must be made artificially equal, by the insertion of appropriate resistances.

Artificial resistances.—The Western Union company use for this purpose, cylinders of plaster of paris, having spiral grooves in their surfaces, in which German silver wires are wound. A metal plate, carrying a screw-post, is fastened at each end, the wire of the coil being fastened, by the shoulder of a small screw, to the plate, while the screw-post serves for the line connections. The cylinders are all of the same size—six inches long by two in diameter—but the grooves are of varying sizes to admit of coarser or finer wires being wound therein. These coils are connected with the line or battery at the switch, by means of a double conducting flexible cord attached to the terminals of the coil at one end, and a wedge to enter a spring-jack at the other; or, are connected in the battery wires, permanently, before the latter enter the switch.

Danger from wires being heated.—A disadvantage about this system, lies in the danger of the wires being heated by an undue proportion of current, caused by a long wire becoming "ground-

ed," or by a resistance coil or coils being removed from a very short wire. One or two accidents have already occurred from this cause, and will doubtless recur, unless proper precautions are taken. An automatic safety-valve or pressure-gauge which prevents this accident, has been devised by Mr. George B. Scott, superintendent of the Gold and Stock Telegraph Company, for use on the lines in his charge. The apparatus consists of a coarse wire magnet, whose armature, sustaining an annunciator "drop," is normally held away from the core by a stout, adjustable, spiral spring. When the current is of normal strength this armature holds four platinum points in contact, arranged in two sets of two points each. The main line current passes through the single spool of the magnet, and then through the two contact points in succession, and then out to line again. If the current be increased in quantity, the armature is attracted and the drop falls. This breaks the circuit at the platinum points, and as there are two, and they both separate for two inches or more, no spark can pass; the circuit is opened and remains so till closed by the attendant. At the same time the drop closes a local circuit and rings a vibrating bell, while a number plate is displayed to show which circuit is open. The use of this apparatus will render accidents from heated wires impossible.

In use on the quadruplex apparatus.—In applying the dynamo-electric machine currents to use on the quadruplex apparatus a difficulty was met with, in regard to the paths followed by the incoming currents, and the necessity for so arranging the resistances that these paths should be equal, under all of the varying positions of the sending apparatus, was apparent. A satisfactory arrangement has, however, been applied in practice, so that these resistances can be calculated for any line.—*The Electrician.*

"As long as the employment of the telegraph was limited, and the number of instruments in an office was consequently also limited, the annual cost of main-

tenance of batteries formed but a comparatively small item in the general working expenses, but, at the present time, when the number of instruments at head offices may be numbered almost by hundreds, the substitution of mechanical for chemical power at all large telegraphic centers, will in time no doubt be adopted, as experiments have demonstrated that the dynamo-electric machine, possesses many advantages over batteries as at present constructed."

SECTION XVII.

MAGNETISM.

The earliest references to the properties of the magnet occur in the annals of the Chinese nation, who used it as a means of guiding the wayfarer over the vast and trackless plains of eastern Asia, long before it was applied to maritime purposes. The compass, or, as it is even now called in Chinese, *tchi-nan*, appears to have been first used at sea by this remarkable nation about the third century of our era, during the Tsin dynasty.

What is magnetic electricity or magnetism?—It is that form of electricity which exists in the magnet or loadstone.

All electricity consists of force. Magnetism is that variety of force which is directive or polar. Any substance affected with it has two points called poles, which sustain opposite relations of attraction and repulsion to any other substance similarily affected.

What are the properties of the magnet?—They are as follows:

1st. The power of attracting and repelling other magnets.

2d. The power of attracting iron, steel, and some other substances.

3d. A directive property, or the power to take a direction north and south when freely suspended.

4th. The power to cause certain electrical changes in adjacent bodies.

These are reduced by a careful analysis to the simple properties of attraction and repulsion.

What is the loadstone or natural magnet?—A native iron ore, known as "*magnetite*" *magnetic oxide of iron or loadstone.* Its properties was first observed by the ancients, and first found near Magnesia, an ancient city of Asia Minor. This ore is quite abundant in various parts of the earth, but only occasional masses are found which possess the remarkable property of magnetic attraction. Probably the most powerful natural magnets are found in the Hartz mountains of Germany, and in Siberia.

What is an artificial magnet?—A bar of iron or steel which has acquired similar properties by artificial means.

What is the form of a magnet?—Artificial magnets are made in various forms. The *bar magnet* is simply a straight bar of hardened steel. If such a bar be curved so that the ends are brought near each other, it is termed a *horse shoe* or U magnet. If several bars, either curved or straight, are united, a compound magnet, or magnetic battery, is formed.

What does the permanence of an artificial magnet depend upon?—It depends upon the condition of the iron of which it is made; pure soft iron retains its magnetism while under the influence of a permanent magnet only; hard iron retains a portion of the magnetic influence, and hardened steel is found to retain this influence with a considerable degree of permanence, dependent upon the quality and temper of the metal.

What is the armature of a magnet?—A bar of iron or steel of a form suitable to be applied to its poles.

When is a magnet said to be armed?—When its armature is applied.

What are the poles of a magnet?—Two points which possess the greatest power.

What names are applied to these poles?—The one which points north is called the northern and the other the southern pole.

What is meant by "magnetic polarity," or "directive power?"—

The property of taking up a fixed position with regard to the poles of the earth, illustrated by the compass, which is simply a magnetic needle, *i. e.* a light magnet, so suspended that it is free to move in obedience to terrestrial or artificial attractions. When thus suspended and left to itself, it vibrates for a time, and finally settles with its axis in a certain fixed direction, which for most places, is nearly north and south.

Why does the magnetic needle point to the north?—The reason why the needle points in the northerly direction is that the earth is in itself a magnet, attracting the magnetic needle as the ordinary magnets do; and the earth is a magnet as the result of certain cosmical facts, much affected by the action of the sun. These laws have periodicities, all of which have not, as yet, been determined.

A condensed explanation in regard to the needle pointing to the northward and southward is as follows: The magnetic poles of the earth do not coincide with the geographical poles. The axis of rotation makes an angle of about 23° with a line joining the former. The needle does not everywhere point to the astronomical north, and is constantly variable within certain limits. At San Francisco it points about 17° to the east of north, and at Calais, Maine, as much to the west.

At the northern magnetic pole a balanced needle points with its north end downward in a plumb line; at San Francisco it dips about 63°, and at the southern magnetic pole the south end points directly down.

The action of the earth upon a magnetic needle at its surface is of about the same force as that of a hard steel magnet, forty inches long, strongly magnetized, at a distance of one foot.

The foregoing is the accepted explanation of the fact that the needle points to the northward and southward, as given by Professor C. T. Patterson, superintendent of the United States coast survey: "Of course no ultimate reason can be given for this natural fact, any more than for any other observed fact in nature. The inherent and ultimate reason of the existence of any fact in nature,

as gravity, light, heat, etc., is not known further than that it is in harmony with all facts in nature. Even an earthquake is in perfect harmony with, and the direct resultant of, the action of forces acting under general laws."

What is meant by the "dip" of the magnet?—Inclination to the horizon, (the dip) varying with the latitude.

The discovery of the dip of the needle is due to Robert Norman, a nautical instrument maker at Wapping, near London, who is described by Gilbert as "a skillful sailor and ingenious artificer." He found that, after being touched by a magnet, the needle always appeared heavier at its northern end; and making an instrument to determine the greatest angle formed with the horizon, he observed the inclination in 1576 to be 71° 50′

In the early part of the following century the variation of the declination was clearly ascertained, and was attributed by Bond, a teacher of navigation in London, to the motion of two magnetic poles.

State the law of magnetic attraction.—Like poles repel and unlike poles attract each other.

What are the substances termed which are capable of acquiring magnetism?—They are termed magnetics.

Name the leading magnetics.—Iron, steel, cobalt, and nickel. The latter, however, are capable of magnetism in a very low degree only.

(It is maintained that all bodies are either attracted or repelled by the magnet. Those which are attracted are themselves capable of becoming magnetic in some degree, and hence are called *magnetics*, while the other class are denominated diamagnetics. It is found that magnetics when exposed to the influence of a magnet, tend to take a direction parallel to its axis, *i. e.*, the line joining its poles, but diamagnetics, on the other hand, incline to a direction at right angles with that line.)

When is a substance said to be magnetized?—When it has acquired magnetic properties.

How may a bar of iron or steel be magnetized?—In three ways.

1st, by contact with one or more magnetic poles.

2d, by friction with the same.

3d, by the inductive influence of currents of electricity.

In the method first named what principle is to be observed?—Each pole induces opposite polarity next to itself, and the same polarity at a distance. To produce magnetism by a simple contact, the inducing magnet must be quite powerful.

Explain the method by friction.—Draw the bar to be magnetized, from its center to the end, several times over one pole of a magnet, taking care to return it each time *through the air*, and repeating the stroke in the same direction. Then place the other pole in the middle of the bar, and stroke the *opposite* end as before. There are, however, several other methods of developing magnetism in a bar of iron or steel, by the inducing influence of a permanent magnet.

How may a magnet be made to lose its properties?—By heating, by violent blows, by disuse, or by friction or induction, the opposite to that which developed its magnetism.

(In reality, neither heat nor blows tend in themselves to produce or destroy magnetism. The state of molecular agitation which they produce seems favorable to a change of magnetic state. Accordingly, it is found that bodies are more easily magnetized while subjected to their influence, and it is probable that under the same influence magnetism is destroyed simply by the attraction of the separated electricities in each particle.)

What is magnetic induction?—The influence of a magnet operating at a distance. The strength of that influence depends upon the distance which intervenes between the magnet and the bar of iron; it is greatest when they are in actual contact. The locality immediately surrounding the magnet is called the "magnetic field."

When a magnet exerts the inductive power upon a piece of iron in its vicinity, is its own magnetic intensity diminished?—It is not but is *absolutely increased.* This is due to the reactionary influence of the magnetism which is induced in the iron. For this reason magnets are furnished with armatures of soft iron, which not only prevent the loss of magnetic powers, but also sensibly increase it. Magnets also react upon each other in a similar manner.

What takes place when a magnet is broken?—Each part becomes a new magnet with two poles of its own.

Is it possible to obtain a magnet with one pole only?—It is not. Experiment renders it probable that the opposite polarities reside in every particle of a magnet: that magnetic induction separates the pre-existent electricities of each particle, but prevents their passing from one particle to another. In the case of soft iron, as soon as the inducing cause is removed the separated electricities instantly unite again, by their mutual attraction, but in the permanent magnet they remain separated.

According to this view a common magnet is a collection of millions of infinitesimal magnets, and the poles of the former owe their power not to any force inherent in themselves, but to the combined action of the forces residing in the myriads of magnetic particles.

How is a magnet affected by use?—It increases in strength by use until it reaches its highest power.

SECTION XVIII.

ELECTRO-MAGNETISM.

It appears that the deviation of a magnetic needle when submitted to the action of a current of electricity, was first observed and published in 1802, by Romagnosi, a physicist of Trent, although the honor of the important discovery of electro-magnetism has been given to Hans Christian Oersted, professor of natural philosophy at Copenhagen, who, in 1819, found that when a magnetic needle (which is so suspended that it may assume a directive position) is brought near a wire in which a voltaic current is moving, that it is influenced by such current as it would be by another magnet, no matter what metal is used for the conductor.

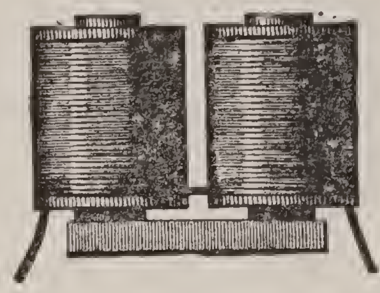


Fig. 4.—ELECTRO-MAGNET.

What is electro-magnetism?—The magnetism which is developed by the influence of electric currents.

Where are electro-magnets most usefully and extensively employed?—In the telegraph. To them it mainly owes its efficiency.

The common systems of telegraph depend entirely upon the electro-magnet.

How is magnetism induced by a current of electricity?—By passing it in a spiral coil around the bar to be magnetized. Such

a coil is usually made of copper wire insulated by being covered with silk or some other non-conductor, and is called a helix. A magnet produced in this way is termed an electro-magnet.

Why is the wire covered with silk?—To insulate it so the current will follow the whole length of the conductor.

How is soft iron affected by magnetism?—It receives and parts with it readily. Indeed, magnetism may be produced and destroyed in soft iron several thousand times in a second. For this reason *soft iron* magnets are altogether used for telegraphic purposes.

Is hard iron or steel similarly affected?—No; they are magnetized slowly, and retain magnetic properties permanently. For this reason artificial magnets are made of steel.

For telegraphic purposes, what can you say about electro-magnets?—They consist of two cores of soft iron, upon which is wound insulated copper wire; each covered with a casing of polished vulcanized rubber, having round heads of rubber or wood, thus making spools of each, and screwed to an iron connecting bar called the "heel piece." See fig. 4.

What is the size and length of the wire wound around the spools?—The size and length of the wire vary according to the purpose for which the magnet is designed.

In the construction of electro-magnets for telegraphic purposes, what principles should be taken into consideration?—1st. As much of the wire as possible must be wound next the core itself, in order that the distance over which the inductive influence must act may be as short as possible.

2d. The *diameter* of the coil should be small in proportion to its length, for the same reason.

Should the spools be wound in the same direction?—Yes.

How should the ends of the wire be joined?—Both inside ends

should be joined. If one inside should be connected with one outside end the current through one helix would neutralize the effect of the other helix, and no magnet be produced. The outside ends should be left free for attachment to the battery or other conductor.

How is the power of the electro-magnet increased?—By an increased number of turns of wire in the coil, although the influence is lessened by increase in the distance between the conducting wire and the core, the outer coils acting less powerfully than those beneath, because of the increased resistance, and as nearly all the magnetic force of an iron bar accumulates at the ends, or poles, a certain arrangement of the wire on the spool cannot be deviated from.

Should the magnet wire around the spools be the same size for the main lines as for local or short circuits?—No; for a long line the coil should consist of longer and finer wire, and for a short or local circuit shorter and larger wire.

Why is this?—Because the maximum of magnetic power is obtained when the resistance of the coil or coils of the instrument or instruments is equel to the total resistance of the remainder of the circuit.

How is the electro-magnet affected by currents of electricity?—The current passing through the numerous turns of the spools causes the soft iron cores within to become magnetic, possessing the power of attracting with considerable force, any piece of iron brought near the ends or poles, and ceases this attractive power the moment the current ceases.

What then does the actual power of the attractive force directly depend upon?—The power of the current supplied by the battery.

What is residual magnetism?—When iron or steel is in contact with an electro-magnet, there will be a slight adhesion, even after the magnetizing current ceases. But when this adhesion is once broken it disappears entirely. This slight remnant of

attractive power is called residual magnetism. It must be carefully observed that it affects only bodies in contact.

SECTION XIX.

THERMO ELECTRICITY—ATMOSPHERIC ELECTRICITY—ANIMAL ELECTRICITY.

What is thermo electricity?—Electric currents produced by the agency of heat. Heat is developed, if the passage of an electrical current through a conductor be obstructed in any manner. It has also been ascertained that any obstruction to an equal propagation of heat in a conducting circuit will produce a current of electricity.

Who made this discovery?—Seebeck, of Berlin, in the year 1822, made this important discovery.

Explain the manner in which thermo-electric currents are originated?—Let a copper wire be separated, and each half fixed into one of the binding screws of an astatic galvanometer. If one of the free ends of the wires be now heated and pressed against the other, an electric current will be generated, passing at the juncture from the hot to the cold wire. If platinum be substituted for the copper the current will be stronger. If two unlike metals, such as antimony and bismuth, or brass and German silver, be soldered together, and the point of juncture heated, an electrical current will also be produced. Such a combination is termed a thermo-electric pair; if several of these pairs be united, a thermo-electric pile is formed.

ATMOSPHERIC ELECTRICITY.

"The analogy between the electric spark and lightning was noticed at an early period of electrical science. In 1708 Dr. Wall pointed out a resemblance between them. In 1735 Grey *conjectured* their identity, and that they differed only in *degree;*

and in 1748 the Abbé Nollet reproduced the conjecture of Grey, attended with more substantial reasons; but it was reserved for the great American philosopher, Franklin, in June, 1752, to *demonstrate* the identity by the bold experiment of bringing down lightning from the clouds by means of a kite raised immediately before a thunder storm, and by performing with it experiments similar to those usually made with ordinary electricity."

What is the most common and striking manifestation of electricity in nature?—The light produced in the clouds during, or before a thunder storm, called "lightning," and may be divided into three kinds: First, forked lightning; second, sheet lightning; third, ball lightning.

What is the lightning?—A discharge of electricity between two or more clouds, or between a cloud and the earth.

How is it caused?—It is caused by opposite electricities accumulating separately, until their mutual attraction becomes so great that they overcome the resistance of the air and dart together.

What produces the accompanying thunder?—The violent commotion of the atmosphere caused by the passage of the electrical discharge.

"Thunder clouds have plates or strata. The discharge of electricity to the earth takes place in the lower cloud, and what is called sheet or heat lightning is that which undulates silently between the lower and upper clouds without any report. Hence thunder storms generally prevail in the lower regions of the atmosphere, and are the most frequent and violent within the tropics, decreasing in frequency toward the poles. They are generally attendant with an alteration of the wind and temperature, and are conducive to health and purity of the air we breathe.

"Forked lightning, however, is only held to be true electricity. The second kind is the most frequent, and is held to be due to the combustion of hydrogen in oxygen, and other chemical changes.

"Ball lightning is probably not electricity, but a mass of gas in intense ignition. The comparative harmlessness of the last two would seem to indicate their non-electric character."

What is the theory of lightning rods?—They protect the building on which they are placed, either by conducting the discharge to the earth, or by quietly neutralizing the electrified cloud by discharging opposite electricity into it.

Has nature provided any lightning rods?—"Yes. Providence has provided a harmless conductor in every leaf, spire of grass, and twig. A common blade of grass, pointed by nature's exquisite workmanship, is three times more effectual than the finest cambric needle, and a single pointed twig than the metallic point of the best constructed rod."

Explain Franklin's kite experiment.—"He prepared his kite by making a small cross of two light strips of cedar, the arms of sufficient length to extend to the four corners of a large silk handkerchief stretched upon them; to the extremities of the arms of the cross he tied the corners of the handkerchief. This being properly supplied with a tail, loop, and string, could be raised in the air like a common paper kite; and being made of silk was more capable of bearing rain and wind. To the upright arm of the cross was attached an iron point, the lower end of which was in contact with the string by which the kite was raised, which was a hempen cord. At the lower extremity of this cord, near the observer, a key was fastened; and in order to intercept the electricity in its descent, and prevent it from reaching the person who held the kite, a silk ribbon was tied to the ring of the key, and continued to the hand by which the kite was held."

Name some other natural exhibitions of electricity.—Electric storms, aurora borealis or northern lights, and earth currents. Also in the attractive power of the loadstone or natural magnet, this power depending upon the presence of magnetic electricity or magnetism.

What are electric storms?—Atmospheric disturbances, in consequence of which the former becomes heavily charged with electricity in certain localities.

What is the cause of electric storms?—Many theories are advanced, but the real cause is probably unknown, although the fact seems to be pretty well established by many circumstances and observations, that the periodic bright spots on the sun are in some way associated with the storms and aurora. The sun spots are periodic, that is the periods of maximum average eleven years, or rather every tenth to thirteenth year they occur. These sun spots we now know as revealed by the great telescopes, are storms of inconceivable extent and violence, sweeping with fearful rapidity over the surface of the sun. When this is the state of the sun the electric pulse of the earth seems to respond, and we have many splendid displays of aurora. This being the case it can hardly be doubted that when the sun is in this state of tremendous commotion, electricity plays a prominent part in the nature of *induction*, produces the phenomena of electric storms and aurora, the infinite distance which intervenes between the sun and the earth offering no obstacle to the inter-action of the electrical force. The electric storm of November 17, 1882, which produced instantaneously such violent and widespread electrical disturbances over a wide extent of territory is regarded as the most violent since 1859.

ANIMAL ELECTRICITY.

What is animal electricity?—Electricity generated in the various organs of animals. Galvani's well known experiment with the frog was the starting point of investigation in this branch of electrical science. Certain fishes have the power of giving strong shocks. On dissection these fish are found to be possessed of very curious electrical batteries, which are so connected with their brains as to be under their complete control. It is supposed that more or less electricity is generated in the various organs of all animals, when in the performance of their proper functions.

PART THIRD.

THE TELEGRAPH.

"Telegraph poles, wires, and apparatus are the levers that move the modern world."

THE EARLY HISTORY AND INVENTION OF THE ELECTRIC TELEGRAPH.

"In vain were efforts made, from the middle of the last century till towards the end of it, to utilize frictional electricity for telegraphing. A pretty apparatus for lecture experiments might here and there be found in use, but any further practical application seemed impossible. The end of the century brought a knowledge of galvanic electricity; and in the beginning of July, 1809, M. Samuel Thomas von Sommering (born in 1755, at Thorn, and a member of the Munich Academy since 1805) constructed the first galvanic telegraph, in which he utilized the phenomenon first observed by Carlisle (in 1800), that the galvanic current decomposes water into its elementary constituents, oxygen and hydrogen. Sommering covered 27 wires with silk, so as to insulate them, formed them into a rope, and brought the gold point ends of the wires, each of which represented an alphabet letter, into a glass trough filled with water; while, at the other end of the rope, two of the wires could be connected with the poles of a voltaic battery; whereupon gas bubbles began to rise in the trough, at the two wire ends—oxygen at one

and hydrogen, in greater quantity, at the other. Sommering thus always telegraphed two letters at once, the letter of the hydrogen wire being regarded as the first. To announce the commencement of the process an alarm was added."

"The possibility of telegraphing with such apparatus is undoubted; and, as afterwards improved by Schweigger, who reduced the number of wires to two, the telegraph would have been practically available; but as the demand for good telegraph quickly increased, better means were found of satisfying it.

The development of telegraphy took a new direction, however, when Prof. Oersted, of Copenhagen, in the end of 1819, made the observation that an electric current deflects a magnetic needle, when passing near it, out of its normal direction north and south.

To about the same time as the needle and pointer telegraphs reach back also those of the Morse system. Prof. Morse (who died in 1872) has told us that it was in October, 1832, on his return voyage to America, the idea occurred to him of making electricity give durable and audible signals at a distance; and he also then sketched out an electro-magnetic telegraph, and a telegraphic dictionary for the signals, which were formed of dots. It was in November, 1835, he showed his friends in New York a model, differing essentially from the later Morse apparatus, and in which a zig-zag line was drawn by a pencil on a strip of paper passing before it." But it was not until 1844 that the Morse system was successfully put in operation by the building of the experimental line between Washington and Baltimore. The honor of the invention of the electric telegraph, however, must be divided among many illustrious names; no single individual can justly claim the distinction. "It was, in fact, a growth rather than an invention, the work of many brains and of many hands." But the well deserved honor remained for Professor Morse to bring the *electric magnetic telegraph* into commercial use, by the invention of the alphabetic charac-

ters, and the practical adaptation of previous discoveries to the end in view.

SECTION XX.

RELATION OF CIRCUITS AND INSTRUMENTS.

How many classes of circuits are there upon a common telegraph line?—Two; main and local.

Define each.—The main circuit is that which extends the entire length of the line, of which the telegraph wire from station to station forms a part.

The local circuit is a short one confined to the office where it is used.

How many of the latter are there on a line?—As many at least as there are offices, and sometimes there are more.

What battery is used upon each circuit?—The gravity battery.

When is a person said to break or open, and when to close circuit?—A person breaks or opens circuit when he interrupts communication so that the electrical current ceases. He closes when he restores communication again.

What instruments are commonly employed in transmitting and receiving messages?—The key, register or sounder, and relay.

With which circuit is each connected?—The key with the main, the register or sounder with the local, and the relay with both.

What is the office of the key?—To open and close the main circuit.

What of the main circuit?—To operate the relay.

What of the relay?—To open and close the local circuit.

What of the local circuit?—To operate the register or sounder.

Explain then, in brief, the relation of the various instruments and circuits.—The key opens and closes the main circuit, the

main circuit operates the relay, the relay opens and closes the local circuit, and the local circuit operates the register or sounder.

What is the difference between what is known as the open and closed circuit system?—"The difference is that in the open circuit system the batteries are always detached and the line connected to the ground at each end when not in use. A main battery of sufficient power to work the entire line is required at every station, which is used in transmitting from that station, but is idle at all other times. In the closed circuit system, on the other hand, there is always a current upon the line, and only one battery is required for the whole circuit, though it is better to divide this and place half at each end, if the line is of considerable length. The closed circuit system is universal in this country, while the open circuit is more common in Europe."

What are the different modes of transmission to distant points?—Hand transmission, called *key telegraphy;* mechanical transmission, called *automatic telegraphy;* verbal transmission, called *telephony.*

How is the speed regulated at which messages can be sent?—I. The *speed* at which messages can be sent is regulated by the number of currents required to form each signal, and by the rate at which the successive currents of electricity which determine the signal can be sent. Hence we have *ordinary* and *fast-speed* telegraphy.

II. The capacity of the wire for the transmission of messages is also regulated by the number, which can be *simultaneously* transmitted. Hence we have MULTIPLEX telegraphy.

Explain, in brief, key telegraphy or hand transmission.—It is simply a systematic putting on and taking off the current, the cessation being equally as important as the continuance of it.

Does a message have to be forwarded at every office it is to pass?—No; for when a line is in a normal condition, *every key* in the

same circuit *always* operates *every* machine situated in it at the *same instant* and in the *same manner.*

Then what is the basis of the Morse telegraph system?—The duplication at one point by the magnet, and its armature of the motions made on the key by the hand of the operator at another separate and distant point.

SECTION XXI.

THE LINE OR MAIN CIRCUIT.

It is of the utmost importance that the line should be well constructed and thoroughly insulated. Although the first cost of a properly constructed line may be greater than that of a line erected with less care, the extra cost will be more than compensated by the greater immunity from those defects which are prolific sources of vexatious delays and interruptions, with their consequent losses. Especial attention should be given to the details respecting the size and sinking of earth plates where water or gas pipes are absent, and the proper soldering of all line connections.

Of what is the main circuit composed?—Chiefly of the following parts:

1st. The metals and liquids of the main batteries.

2d. The telegraph wire from office to office.

3d. A loop from this wire passing into each office and including the key and relay helices.

4th. The earth.

What three essential parts does the line as ordinarily constructed consist of?—The *poles*, *wires*, and *insulators*.

What kind of timber is used for poles?—Red and white cedar, chestnut, redwood, juniper, and cypress.

Give some details regarding the preparation of poles before setting.—"Neither green poles nor those having the bark upon them should be used. They should be cut in the winter, at least six months before they are brought into service. The bark should be carefully removed, and the poles should be stacked in such a manner that the air may have free circulation among them, the lowest tier being several inches from the ground. They should also be protected from the direct rays of the sun, as they will be apt to split if allowed to dry too rapidly. The butt-ends of the poles should be charred to the distance of a foot above the ground line before they are used. If it be impossible to procure seasoned poles, the bark should be removed as before, and the butts should be thoroughly baked and charred. Green poles should not be tarred, as the timber is thereby prevented from drying, and decay speedily ensues. The poles should not be painted until several months after they are set in the ground, and should never be painted in wet weather, nor before they are thoroughly dry."

What is the length and size of the poles on an ordinary line?—The length and size of telegraph poles depends upon the locality and the number of wires they are to carry. The length of poles are from twenty-five to thirty feet, and a diameter of at least six inches at the top. On principal routes and in the streets of cities longer and larger poles are used.

How deep are they set in the ground?—On an ordinary line poles should be set in the ground to a depth of about five feet, and in passing around an angle or curve lean against the strain, and when practicable on the inside of the curve of a railway, and should be set a uniform distance of 25 feet from the track, in order to clear the track if they should fall. "The holes should be dug as narrow as possible and perpendicular at one side, so that the pole will have one side of solid earth, and the earth well tamped down as replaced."

What should be done to strengthen the poles at angles and

curves?—The effective fixing of struts, stays, or guys, should be employed, before the wires are attached.

What is the distance between the poles?—The distance varies according to the curves and nature of the ground, probably about thirty to the mile is the average.

Which side of a railway should the poles be erected?—The pressure of the wind on the poles and wires in a gale is very great, therefore they should, when practicable, be erected on the *lee side* side of a railway, in order to be sheltered from the prevailing winds. Where the line runs north and south the east side should always be chosen.

What is the average period of the usefulness of a pole under ordinary circumstances?—The soil in which they are set, and also the atmosphere and sunlight has much to do with their life, for if one breaks off at the surface of the ground, or near the surface, as is usually the case, it will be five feet or more shorter than the others, and hence it is generally regarded as unfit to re-set, and a new one must take its place. In some locations this is provided for by having all the poles long enough to re-set if they are sound enough for it to be economical to do so.

When considered apart from any local catastrophe or universal storm, the poles which are cut in winter are found to last as follows, according to the wood used, without being renewed: Cedar, 16 years: chestnut, 13 years; these are used in the Eastern, Middle, and Western states; juniper and cypress are used in the Southern states, and redwood is used in California. Spruce lasts seven years and juniper thirteen years. If poles are cut in the summer their life will be about five years shorter than if cut in the winter. It is seldom that mixed woods are used on a line; they are all of one kind of wood.—*Journal of the Telegraph.*

"The official return of the Western Union Telegraph Company to the Superintendent of the United States Census, in July 1882, shows the following facts as to the poles used during the year: Average length of poles, 27 feet; diam-

eter at top, six inches; kind of wood used, cedar, chestnut, juniper, cypress, and redwood. These poles were obtained in all parts of the United States and in Canada. The average cost of each pole delivered without freight was one dollar and two cents. All these poles were round except about one-fiftieth, which were sawed or squared. No process was used for preserving poles, and their average life, according to the wood used and the location where set, was twelve to fifteen years, and most durable wood in favorable situations did not exceed twenty-five years. The woods preferred were red cedar, white cedar, chestnut, and redwood."

What kind of wire is employed for the line?—Although copper is a better conductor than iron, yet it is more costly and not so strong, hence the latter is used. The sizes usually employed on ordinary lines are Nos. 8 and 9, and for very long lines Nos. 4 and 6. For short private lines or telephone lines, Nos. 11, 12, and 14 are generally used. The longer the line the larger should be the wire, as the larger the wire the better the conductor. The smaller wire offers greater resistance to the passage of the current, *and, consequently*, much greater care must be exercised in the insulation of the line. The increase of resistance also virtually adds to the length of the circuit, rendering necessary an augmentation of battery power.

What is done to preserve the durability of wire and protect it from rust?—The wire is, or should be zinc-coated, or what is more familiarly known "galvanized." The zinc-coated wire has proven very durable in most localities. In smoky places, however, where large quantities of coal are daily consumed, the sulphurous vapors produced thereby attack the zinc coating, and the wire is often speedily destroyed. This may be prevented to a great extent, by varnishing or painting the wire when putting up.

How long will ordinary telegraph wire last?—The falling of a pole generally does much damage to the arms, insulators and wires. If they were all put up new at once, plain wire will last from twelve to fifteen years, and the galvanized wire used at the present day, being the best conductor, will last in the most favorable atmosphere for from sixteen to twenty years, but no longer,

and where there are strains by poles or wires falling they will not last so long, and in cities and large towns, where there is much gas and moisture it will not last more than two or three years. At all events, when a line begins to be about ten or twelve years old, and has plain wire, it is regarded as unreliable, and the safest and most economical way is to rebuild it, throughout, of new materials. The cost of constant repair and isolated and frequent transportation of posts and other material, and the labor of repairs and re-setting, cost almost as much in a short time as it would to rebuild. Under the usual course of things a telegraph line thirty-six years old, has been entirely rebuilt at least three times, and in many cases nearly four times.

The trunk lines of the Western Union Telegraph Company were first built more than thirty years ago, and nearly all of their lines have been rebuilt at least once. Where a line is built for only a few wires and it is proved that more are required it is then necessary to rebuild it entirely with longer poles, and in such case all wires are also put up new, if they are expected to be in constant use.—*Journal of the Telegraph.*

What is the weight per mile and resistance of the wire generally used for telegraph lines?

No.	4	weight,	730	pounds.	Resistance,	6	ohms.
"	6	"	540	"	"	10	"
"	8	"	385	"	"	14.1	"
"	9	"	330	"	"	16.4	"
"	12	"	168	"	"	32.7	"

The Birmingham wire-gauge is generally regarded as the standard, but it is not really one gauge, but an approximation only, as different manufacturers do not agree in sizes.

What should be the principal qualities of telegraph wire?—The wire should be soft and capable of stretching from fifteen to twenty per cent. before breaking, and bear bending backwards and forwards several times without fracture. The breaking

strain of wire should not be less than two and a half times its own weight per mile. It should also be required to bear without splitting or breaking, a certain number of twists when placed between two vises about half a foot apart; the more twists it will bear without fracture the better its ductility.

What terms are applied to the different qualities of telegraph wire?—"*Extra Best Best*," (Ex. B. B.), a term applied to the wire which stands highest of all in conductive power, manufactured from the *very best iron*, pure and uniform in quality, and very tough and pliable, weight per mile ohm, of from 4,600 to 5,100 lbs. "*Best Best*," (B. B.) a term applied to the quality of wire less uniform and tough, but stands a good mechanical test, is used very largely in the telephone service, and almost exclusively by some large telegraph companies and for railway telegraph lines; weight per mile ohm, 5,500 to 5,800 lbs.

"*Best*," (B) a term almost indiscriminately applied to the lower grades of wire designed for electric service; a harder and less pliable wire; about 6,500 lbs. weight per mile ohm.

Are wires affected by the extremes of summer and winter temperature?—Yes. Especially in the northern states, which usually causes a variation of from three to four feet per mile in the length of an iron wire.—*Prescott.*

Does the temperature affect the resistance of wire?—Yes. As the temperature of a metal increases or diminishes, so does its resistance. Iron wire increases in resistances 0.21 per cent for each degree (Fahr.) through which it is raised, and owing to the diurnal variations of temperature in our climate, considerable difference must be experienced in the resistance of the wire as between midday and midnight.

What is the meaning of dead wire?—In large cities the almost innumerable net-work of wires belonging to different corporations, necessitate frequent attention. Frequent changes in the systems produce wires that, though left standing, are disused.

These are called *dead wires.* Each company keeps a chart of its wires, and whenever the use of any wire is discontinued the fact is noted on the chart, so that when occasion requires it the wire may be used again. When old wires are replaced by new the old wire is collected and sold.

What is meant by skin wires?—Skin wires are those put up without authority. Whenever these are discovered, however, they are unceremoniously cut down. Where they come from or who puts them up it is sometimes impossible to tell.

What is the meaning of "phantom wire"?—Additional circuits created by the introduction of duplex and quadruplex system of telegraph.

Are covered or insulated line wires ever used?—Yes; it is a necessity to use covered wires to prevent contact and crosses in some localities in cities, especially house-top wires, on account of the great number of such wires which cross and recross each other, often not over an inch apart.

To obviate this evil and do away with the nuisance of so many aerial lines in cities, many underground systems of telegraph have been proposed, but as yet, owing principally to the enormous expense, none have been generally adopted in this country. However, extensive underground systems are in successful operation in European cities, which thoroughly demonstrates its feasibility.

Fig. 5.

How should wires be spliced?—The two ends should first be brightened, and then each wire should be firmly wound around the other, the different convolutions touching one another, and passing as near as may be at right angles with the wire, which they surround. Not less than five or six turns of each wire should be made, and the ends cut off short (see fig. 5). A splice should

never be made by turning the wire back, and wound upon itself forming a loose loop. To insure a perfect joint, all splices should be soldered.

Should the wires be strung on the poles as soon as set?—No; the poles should be allowed to stand a sufficient time to allow the earth to settle around them, and become firm before the wires are placed upon them.

What precautions should be observed in stringing wire?—Wires of different gauges should not be placed upon the same supports, as they are apt to form contacts, as they do not swing in time when blown by the wind. However, when it becomes necessary to use wires of different weights, the lighter wires should be placed above the heavier ones. Great care should be observed to give the wires the proper "dip" or "sag," between poles, or points of support, especially where a number of wires are strung on the same supports. When strung in summer they should not be pulled up too tightly, or they will be liable to break from the action of the winter frosts, and the poles are liable to be torn up by the contraction of the wires. On the other hand, if wires put up in cold weather are allowed too much "dip" they are very liable to form contacts in summer. A wire should never be subjected to more than one-third of its breaking strain.

What should be done to prevent escape of current where it is impossible to run the wires free from the branches and leaves of trees?—Loss of current may be partially if not wholly prevented at such places by using "covered wire," or covering the wire with tarred tape.

How is the main line insulated from the earth?—By being supported in the air upon poles by insulators made wholly or in part of glass or some other non-conducting material.

In case of aerial lines, insulation at the points of support is considered sufficient; but when the line is carried through damp

tunnels, or under ground, or through water, the insulation must be continuous, which is effected by covering the wire with gutta percha, vulcanized rubber, or "kerite," the latter recommended as giving very gratifying results.

What is said of the construction of the glass insulators?—They are formed so as to give the greatest possible length of insulating surface between the line and the supporting pin or bracket, the under surface concave, to prevent accumulation of moisture on that part in wet weather, and a screw thread upon the inside of the socket, which fits into a corresponding screw cut upon the wooden supporting pin or bracket.

How is the line secured to the insulator?—By a tie wire, which passes around the insulator in a groove, and the ends wrapped around the line wire.

Is glass a perfect insulator?—This insulator, like all others, is open to several objections. Its chief deficiency lies in the fact that in damp weather it is liable to be covered with a film of moisture which furnishes the current a means of escape.

What characteristics should a perfect insulator possess?—It should have the smallest possible diameter consistent with strength; the distance between the wire and bracket should be as great as possible; the material of which it is composed should be a non-conductor of heat and electricity; it should not absorb moisture, but its surface should repel water; it should be unaffected by the vicissitudes of the weather; it should be free from pores and cracks, and it should admit of being readily cleansed. The materials usually employed for insulating purposes are all more or less deficient in the above mentioned particulars. The *glass insulator* is, however, very extensively used in this country, principally on account of its cheapness, but various other insulators have been brought into use to a limited extent, among which may be mentioned the *porcelain insulator* for outside

office use, and general short line work, where the regular insulator is not required.

How are the wires attached to the poles?—When a single wire is run, the wire is attached to the insulator, screwed upon a pin inserted in the top of the pole, or screwed to a wooden bracket, spiked to the side of the pole near the top, far enough below to insure the wire being caught should the insulator become broken. Where a number of wires are run, *cross arms* are used. The insulators are screwed to wooden pins on these arms, placed about twenty-two inches between centres.

What kind of cross arms are used?—Cross arms generally used are of well seasoned white pine planed off and beveled on the upper corners, and painted with two coats of rubber paint—size, four by five inches, and varying in length according to the number of wires to be used.

How are the cross arms secured to the poles?—Commencing near the top they are placed about twenty-two inches apart, one directly beneath the other, in *gains* cut into the pole, fastened by two, and sometimes three *lag screws*, depending on the length of the cross arm. This is called *framing* the pole, and should be done with the pins and insulators fitted before it is set up.

Explain the insulation of loops from main wires leading into offices.—Inside of the office their insulation is effected by covering the wire with gutta percha, silk, cotton, or some similar non-conductor.

How are wires looped into way offices?—There are several plans. The usual method is, to run the wires direct from an office pole to hook or glass insulators on a cross arm securely fastened several inches below the top of the window, and thence, through hard rubber tubes, the outer ends pointing downward, inserted into the top of the window casing above the insulators, so that the wires will lead upward from them; they are then secured inside by screw posts or otherwise, from which the office

wires lead. Or the ends of the wires may be fastened to the insulators, and *kerite covered* wire run through holes bored in the window casing above the insulators, stripping and brightening the ends several inches and winding them around the line wires, first brightening the same.

State another plan.—Another plan is, to cut the line wire and insert a glass insulator, by breaking off the top and running one end of the wire through it, the other around it, and winding the ends back upon the line, and to each side of this, connect wires leading to the office.

How are house-top wires looped into offices?—In various ways, according to circumstances. A common plan is to run the main line to porcelain or hook insulators on a counter brace overhanging the eave, and to drop the loop down to insulators on an arm or on brackets, spiked to the wall close to the window, and connect the leading in wires to these.

What method is employed where there are a great many wires leading into an office?—Different methods are employed; usually the wires are led into the office from an office pole containing a number of cross arms, but this is not always practicable. A good plan, and the one now usually adopted, where there are a *large number* of wires, is to build a cupola on the top of the building, surrounded by several wooden bars securely fastened, one above the other, containing the insulators, and the leading in wires connected to the lines at the insulator and on the inside to screw posts from which the office wires are led.

How do the extremities of the main line connect with the earth?—By connection with the terminal ground wires. *Great care*, however, must be taken to *have the earth connections perfect.* Insulated No. 16 copper wire should be used, and spliced to about six or seven feet of bare copper wire after it is securely connected to an *iron water pipe* or gas pipe outside of the meter. The pipe, however, should be filed or scraped bright

and clean for several inches, and the wire carefully and tightly wrapped around it, each convolution close to the preceding one, and then tightly secured and soldered. If water or gas pipes are not accessible, attach the wire securely to a plate of copper, or iron, having considerable surface, and buried sufficiently deep in the ground to reach moisture at all times of the year Earth currents sometimes occur when the terminal ground wires are attached to dissimilar ground plates or pipes, therefore the terminal wire, should connect with the *same kind of metal* at both ends of the line.

How many main batteries are required upon a line?—Generally two, one at each terminus; but short lines sometimes employ one only. The situation of the battery would matter little if it were possible to secure at all times a perfect insulation of the line. As this condition cannot be secured, however, it is better to divide the battery into at least two sections, and place them one at each end of the line, so that the current may be as nearly equal as possible throughout the entire length of the circuit.

How many cells of battery are required on an ordinary line?—It depends on the number of instruments in circuit—the size and quality of wire, completeness of insulation, etc. Probably one cell of battery to every forty or fifty ohms resistance in the circuit is sufficient.

In connecting main batteries with the line what rule must be observed?—Like poles must never be connected. The wire leading from the positive pole of one battery must join the negative of the next, and the positive pole of one and the negative pole of the other terminal battery, must connect with the earth.

Can more than one circuit be worked from a single battery?—Yes; but the battery must have a very low internal resistance to get good results.

Where several lines diverge from one battery is it necessary that

each should have a terminal battery of its own?—No; one such battery, provided it be of sufficient power, and has the required internal resistance, will operate all of them by division of current, according to their several resistances *i. e.,* if they offer equal resistance, and are equally well insulated.

By this arrangement, it is a singular fact that a battery sufficient for one line will work several with equal facility, provided there be not too great a difference in their lengths. Practically, the limit to variation in length may be stated as follows: Of the several lines operated from one battery either may be long or short as desired, without reference to the length of the others, provided none of them extend less than fifty miles, and provided also, that if either line fall short of that distance, there be introduced into its circuit a rheostat (See Sec. XXIX) of such resistance that line and rheostat together shall offer a resistance equal to that of fifty miles of common line wire.

How many circuits may be worked from one battery?—The number of circuits which may be worked in this manner depends upon the proportion between the joint resistances of the circuits and the internal resistance of the battery. When the internal resistance of the battery is inappreciably small, as compared with that of the circuits connected therewith, but little effect will be produced upon any given line by opening or closing the other, but the sulphate of copper batteries now universally employed, have too high an internal resistance to allow of more than about *three lines* being worked from them satisfactorily.

Is there any objection to this system?—Yes; the principal objection is that, in wet weather the resistance of the circuits is greatly diminished, which necessarily determines the interference of one line with another, and as the battery necessarily becomes exhausted sooner than if it had but one line connected, the consumption of material being exactly in proportion to the work done, there seems to be no economy in working several lines from one battery. However, this mode of working is quite general in America, but it is advisable, in case of failure, never to have less than two distinct sets of batteries at one station.

How may the power of the battery as well as the character of

its effects be modified?—This may be done by grouping the cells in various numerical relations.—For example, six cells may be arranged in consecutive order, in which case we have the maximum of *electro-motive force* possible with that number. If such a battery be arranged in two groups of three cells each, the quantity will be doubled, but the *electro-motive force* will only be half as great as in the former instance. Such a battery may also be arranged in three groups of two cells each, and finally, each zinc and each copper may be joined to a common conductor, each on its own side, by which arrangement the greatest quantity effects of the battery are obtained, whilst the combination possesses the electro-motive force of only one couple.

The principle of grouping the battery cells should be well understood as it may prove of great practical service when desired to produce certain effects, as in case of a heavy escape of the current on the line; many operators would increase the electro-motive force of the battery, by adding more cells; according to the first method, it would be much better if the extra cells were added in such a manner as to increase the quantity of the current, rather than its electro-motive force. If the quantity be increased, the loss caused by the escape is at least partially repaired; but an increase of electro-motive force only tends to aggravate the evil which it is desired to remedy, by urging the electric current over the escape to the ground with greater energy.

How does the main battery afford communication between distant places?—By controlling the operation of relay instruments in all those places. Thus, a person at any part of the main circuit can, by opening and closing it, direct the action of the relays throughout the entire circuit, though it extend several hundred miles.

What is the average length of a single circuit?—One hundred and seventy-five or two hundred miles.

Circuits three or four hundred miles long are not uncommon, and in a few instances single circuits have been worked through a distance of one or even three thousand miles.

If perfect insulation could be secured long circuits could be worked quite as easily as shorter ones, but it has been found impossible to work such long circuits during all states of our variable weather, without the use of repeaters.

The longest span of wire known is used for a telegraph in India, over the

River Kistuah, between Bezorah and Sectanagrum. It is more than 6,000 feet long, and is stretched between two hills, each 1,200 feet high.

State in brief the course of the main current.—Starting from one main battery, it passes along the wire, through the lightning arrester, the switch, key, and relay helices in each office, through the intermediate main batteries, if there are any, to the terminal main battery; thence it continues on to the earth by the ground wire, and in effect through the earth back to the ground wire of the first battery, and by that to its starting place, and so on.

Does the current really pass back through the earth?—Probably not, though the effect is the same as would be produced if it did so.

What is the explanation of this phenomenon?—The earth must be regarded as a reservoir of electricity which yields up to one end of the line as much as it receives from the other, without permitting any "increase" or "decrease" of its electricity. However, on this subject scientists differ in opinion, but the fact remains, that for all practical purposes the earth may be used as a return wire.

In reference to this phenomenon, Mr. W. H. Preese, electrician of the post-office telegraph system of England, says: The discovery of the *telephone* has enabled us to establish beyond doubt the fact that currents of electricity actually traverse the earth's crust. The theory then that the earth acts as a great reservoir for electricity may be placed in the physicist's waste-paper basket, with plogiston, the materiality of light, and other hypotheses. Telephones have been fixed upon a wire passing from the ground floor to the top floor of a large building, the gas pipes being used as a return, and the Morse signals sent from a telegraph office two hundred and fifty yards away have been distinctly read; in fact, if the gas and water systems be used, it is impossible to exclude telegraphic signals from the telephone circuit. There are several cases on record of telephone circuits miles away from any telegraph wires, but in a line with the earth terminals, picking up telegraphic signals. When an electric light system uses the earth, it is stoppage to all telephonic communication in its neighborhood. The whole telephonic communication of Manchester was one day broken down from this cause, and in the city of London the effect was at one time so strong as not only to destroy telephonic communication, but to ring the bells. A tele-

phone circuit, using the earth for return, acts as a shunt to the earth, picking up the currents that are passing, in proportion to the relative resistances of the earth and the wire. The earth offers resistance, and consequently obeys the laws of Ohm.

By whom and how was the discovery made that the earth could be used to complete one-half of the circuit?—This important discovery is attributed to Professor Steinheil, of Munich, who in 1838, while making some experiments on the Nuremberg Further railroad for the purpose of determining whether the track could be used for telegraphic purposes, discovered that the current passed from one of the rails to the other by means of the earth. Although it is stated that as early as 1747, Dr. J. Watson, of London, constructed a short telegraph line using frictional electricity and employing the earth for a return wire.

What is the advantage of employing the earth as a part of the circuit?—It saves the trouble and expense of an additional wire for the return current. Also, since the earth opposes no resistance to the transmission of electricity, the battery power thus required for a given distance is only half of what would be necessary if the current was returned by a second wire.

What causes the peculiar humming of telegraph wires at the point of support?—This noise is caused by vibration. *Not* by the messages or electricity passing over the wires as many erroneously suppose.

Is there any device for preventing the noise?—Yes; various arrangements have been devised to remedy the evil—probably the most effective is Clark's device called the anti-hum.

Describe its construction.—It is composed of an ordinary shackle of galvanized iron, provided with a washer or cushion of soft rubber, the wire being cut, and the ends connected to the device; a loop passing around the anti-hum, and connected with the line wire conveys the current.

When the lines are out of order how are they repaired?—By the local repairer within the territory assigned to him, who is re-

quired, when not actually engaged upon the line, to be at all times, day and night, accessible to the manager of the station at the place to which he has been appointed, and is required to have everything in readiness to start on the instant when notified of trouble.

What are the ordinary tools used by repairmen?—Plyers, vises and strap, climbers, splicing clamps, hatchets, pulleys, and tackle.

What is the Ohio law regarding wilful or malicious injury of telegraph lines?—"Any person who shall wilfully or maliciously injure any telegraph pole or wire thereof, upon conviction, shall be imprisoned in the STATE PRISON not more than two years, or fined not exceeding five hundred dollars, and imprisoned in the county jail not less than three, nor more than six months."

SECTION XXII.

THE LOCAL CIRCUIT.

Of what is the local circuit composed?—Chiefly of three parts.

1st. The metals and liquids of the local battery.

2d. The armature lever of the relay and its frame, and the helices of the register or sounder.

3d. Wires connecting these instruments and the battery.

What kind of wire is used for this circuit?—Copper usually, because it conducts better than iron wire of equal size and is sufficiently strong for this purpose, strength not being needed as it is on the main line. As covered copper wire is usually used always be sure to bare the ends where the connections are made.

How is the local circuit insulated?—Its wires are usually covered with some non-conducting substance as silk, cotton, or gutta percha, and the various parts of the instruments upon it are in-

sulated as far as is necessary by being set in dry wood, or other non-conductor.

How many battery cells are used on a local circuit?—Two generally, though one often is sufficient.

What is the extent of this circuit?—Usually but a few feet, from battery to instrument; but in large offices the batteries are kept in a room by themselves, and then circuits leading to instruments are necessarily longer.

State the course of the local current.—Starting from the battery it continues along the wire, through the armature lever of the relay and its frame, and the helices of the register or sounder, then back to the battery, and so on.

SECTION XXIII.

THE KEY.

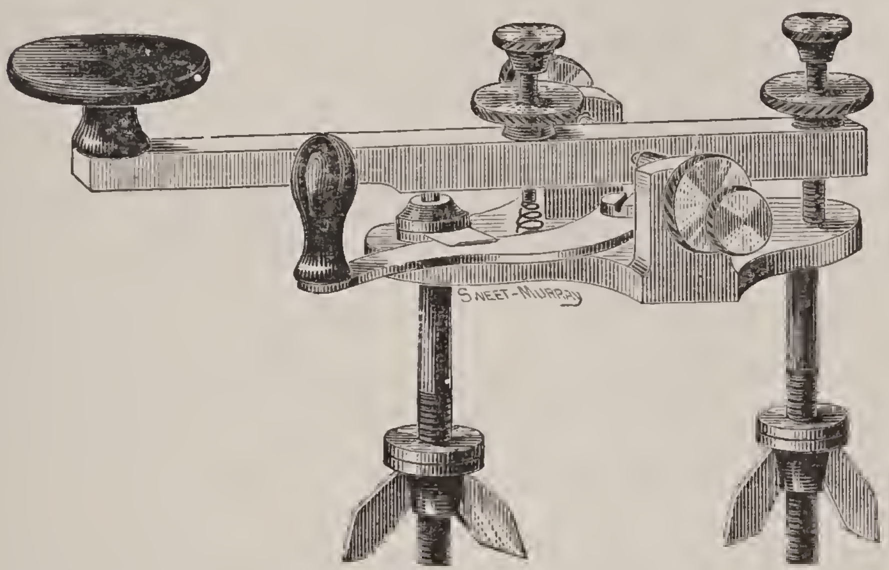


Fig. 6.

What instrument is employed in transmitting messages?—The key—Fig. 6.

What is the key?—A contrivance for opening and closing a voltaic circuit at pleasure.

Describe its construction.—It is made in a great variety of forms, as is every telegraphic instrument. But its essential parts are two metallic conductors insulated from each other, and a movable bar called the key lever, mounted upon a steel trunnion turning between two adjustable pivots, or set-screws. The frame and lever usually constitutes one of these conductors, and the other is a small metallic piece passing through this frame and separated from it by bone, rubber, or other non-conductor.

With what are these conductors connected?—One with one part and one with the other part of the main circuit.

How are they related to the key lever?—The lever is so situated that it always connects with one of them, and may by a slight movement connect also with the other, thus joining the two and closing the circuit.

How is this accomplished?—By means of two platinum pieces called the hammer and anvil. The hammer is attached to the lever and so connects with one part of the key; the anvil is immediately below this and attached to the other part of the key. When the lever is depressed these pieces are brought into contact, and the circuit is closed.

How is the circuit opened again?—By a spring which raises the key lever as soon as the pressure is removed

What is the circuit closer?—A movable bar so situated that it may be made to establish a permanent communication between the separated parts of the key, and should always be closed when the operator is not using the key.

What else is the key provided with?—Set screws for the purpose of regulating its play to suit the hand of the operator, and regulate also the pressure of the spring beneath the lever for the same purpose. The lever is also provided with a knob or button of hard rubber, which the operator grasps in sending.

How is the key fastened to the table?—By means of long

screws, which also hold the ends of the wires, one connected with the base, the other with the other part of the key, passing through and insulated from the base.

If the points in the key stick fail to break circuit what is the remedy?—To rub them gently with a very fine file, or draw between them a strip of hard clean paper or emery paper.

If a key sticks, does it interfere with both sender and receiver?—It does; for the key opens and breaks the main circuit.

What causes a key to stick?—This may be attributed to various causes, the principal one, probably, being the effect of the repeated action of the electric spark which passes between the points every time the current is broken, or it may be caused by metallic dust which accumulates on the points, or through improper adjustment the points do not come squarely together.

What precautions should be observed regarding the key?—The pivot, or set screws, should always be kept sufficiently tight to prevent trouble, and the spring in connection with, and beneath the lever, should always connect with the base.

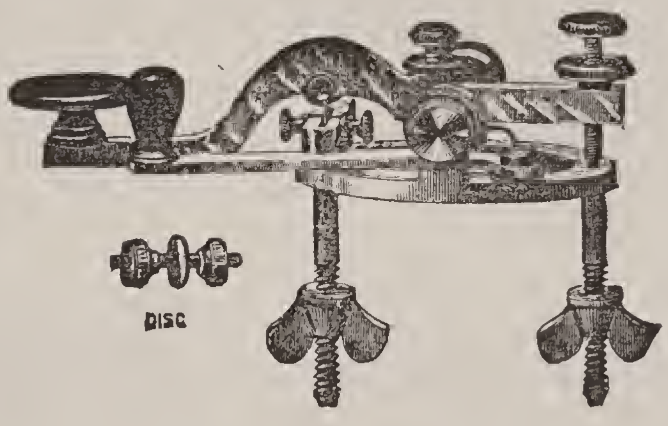


Fig. 7.

Have any improvements been made in telegraph keys?—Keys, distinguished by new and desirable features, designed for durability and rapid sending, have rapidly multiplied within the past few years, among which may be prominently mentioned the Cumming "periphery contact" key, the Bunnell steel lever

solid trunnion key, the Phillips key, and more recently the "Victor key"

The former, as seen in Fig. 7, is the same as an ordinary key in all respects, except in substituting for the ordinary platinum points two little discs with rounded platinum wire tires set at right angles to each other, so that the impinging point is a mere dot or needle point of surface The inventor claiming as a scientific discovery that the smallest surface of contact is the best and only perfect form for electrodes. This opinion seems to be well founded, as the diminished area of metal in contact appears to offer no extra resistance whatever to the passage of the current above that encountered with an ordinary key. The fineness of the contact enables the key to be worked in a very close adjustment without "sticking;" even, it is claimed, to the one one-thousandth of an inch play under an intense dynamo current. Such close adjustment necessarily implies fast transmission, with the least fatigue to the sender, and thus the jar consequent on considerable "play" is entirely avoided. It is endorsed by experts and the inventor has been awarded medals by many international and state expositions. Whatever else may be said of its merits it certainly recommends itself as an extremely economical form for wear, each disc having a reserve on its periphery, equal to at least one hundred ordinary points.

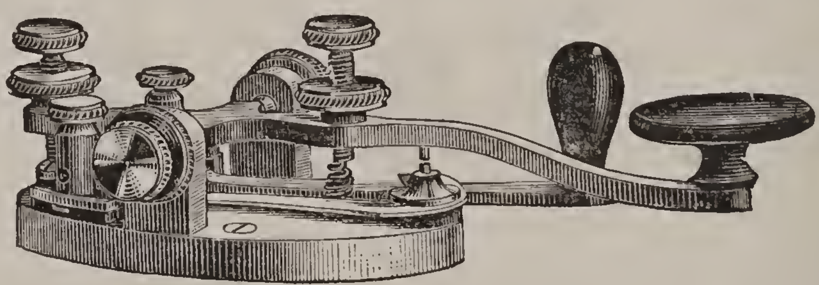


Fig. 8.

The Bunnell steel lever key is regarded as a great improvement on the old style of telegraph key, but is somewhat similar in appearance. Fig. 8 represents a legless pattern of this key.

The improvement, however, possesses much merit, which consists in the fact that the entire lever and trunnion together are comprised of one piece of steel made only *one half* the weight of the ordinary brass lever. The common defect of loose trunnions is thus avoided, and its lightness, size, and proportions combining strength and neatness, with the use of hardened platina points, well adapts it for easy and rapid sending, and is very extensively used on the different telegraph lines.

The Phillips key, as constructed, is claimed to prevent "sticking." Its chief merits consist in substituting hardened steel points for the ordinary platinum points. The lower point is removable, and can be readily cleaned when discolored, while new points can be substituted for the old ones, as occasion may require, without removing the key from the table or disturbing its adjustments in any manner whatsoever.

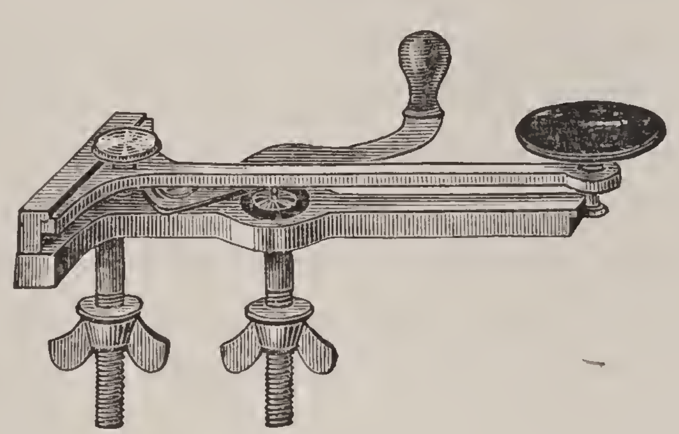


Fig. 9.

The Victor key, Fig. 9, is probably the most radical change in the style of the key, and consists of a light steel lever set in the frame the entire width of the base, forming a good connection with the latter, and at the same time producing an easy motion directly up and down without side motion, dispensing altogether with trunnions and the back adjusting screw, the play of the lever being regulated by turning the knob. The top bearing of the lever spring is *above* the fulcrum of the lever, which admits

of extra light or stiff adjustment of the spring without destroying its elasticity.

SECTION XXIV.

THE RELAY.

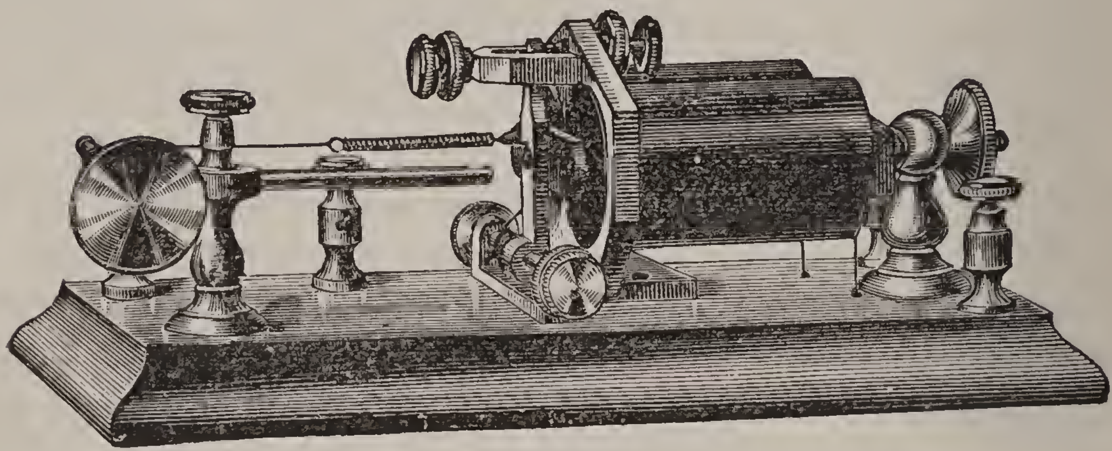


Fig. 10.

What is the relay in Morse's telegraph?—An instrument, whose office is to connect the main and local circuits, in such a manner, that the opening and closing of the former, opens and closes the latter.—Fig. 10.

Does the relay cause any communication of electricity between the two circuits?—It does not. It establishes between them a *mechanical* and *not an electrical* connection.

What are the essential parts of the relay?—

1st. Two helices of insulated wire enclosing two bars of soft iron connected by a yoke, or the two ends of one bar bent in the form of a U magnet, called the cores.

2d. A soft iron armature attached to a movable lever and situated near the ends of the soft iron bar or bars.

3d. Two platinum points, so situated, one of them being fixed upon the movable lever, and the other to the frame, that the movements of that lever may separate or unite them.

State the electrical connections of the different parts of the relay.—Its *helices connect* with, and form part of the *main circuit.*

The *platinum points connect* similarly with the *local circuit.*

How is the distance regulated through which the armature lever moves?—By two adjustable set screws, supported by a metal frame running up from the base, one of them checking the motion toward the magnet, and the other limiting the reverse movement, in which case it is necessary that the point of the set screw, checking the backward movement, be made of some insulating material, such as hard rubber or bone, in order to open the local circuit when the lever falls back.

Explain the action of the relay.—When a current traverses the main circuit it passes through the relay helices, and transforms the soft iron bars within them into electro magnets; the latter then attract the armature which thus moves the armature lever and brings the platinum points into contact, *closing the local circuit.*

When the main current ceases, the electro-magnets cease to attract the armature, which is then thrown back by a spring, separating the platinum points and *opening the local circuit.*

Should the armature be brought into contact with the poles of the magnets?—It should not, for the residual magnetism would then prevent its being thrown back when the main current ceased. However, when the current is very feeble, adjust the armature as close to the magnets as possible without contact.

How is this prevented?—By the screws which regulate the play of the armature in either direction. In most instruments the magnet itself is also thrown forward or backward by a screw near the yoke, so as to accommodate its position to that of the armature.

What is the adjuster?—A contrivance for regulating the tension of the spring which draws back the armature, is capable of extension, and may be fastened in any required position by a set screw.

How is the lower end of the armature lever arranged?—It is mounted upon a steel arbor turning between two adjustable set screws, the latter being mounted upon standards projecting from the lower part of the frame, or a piece of metal with upright standards attached to the base.

Upon what kind of base are the various parts of the instrument attached?—Upon a base of dry hard wood, or of some other non-conductor.

What is the distance through which the armature lever should move?—The distance should be very small, never to exceed one thirty-second of an inch, and when the movement of the lever is very feeble, it should be made as small as possible.

State in brief the object of the relay.—Although powerful batteries be used on an ordinary line, the great resistance offered by so many miles of wire, reduces the strength of the current to such an extent that but a weak magnet can be produced, and the addition of other batteries and instruments in a certain manner becomes a necessity.

Explain the operation of the additional instrument.—The armature of the relay having a motion precisely like that of the key, is converted into one connected with the local battery, and works an instrument called the sounder, in the same manner that the key effects the relay. The movement of the armature is feeble, but powerful enough to open and close the local, which, on account of the little resistance in so few feet of wire, operates the sounder with many times the force of the armature.

Does the current from the local batteries at way stations exert any influence on the main line?—It must be *distinctly* understood, that the main and the local currents NEVER touch each other, and that the local exerts no influence whatever on the main.

What is the only substance in contact with the two circuits?—The air and the wooden base—both of these non-conductors.

If the points in a relay "stick" fail to break the local circuit, what is the remedy?—The same as that for the key.

If a relay "sticks," does it interfere with both sender and receiver?—No; it troubles only the office where that relay is located.

Why is platinum used for the points of the key and relay?—Because it does not readily fuse or tarnish.

What is platinum?—Platinum is a metal the color of silver, but less bright. It is the heaviest and least expansible of the metals, is harder than iron, is very ductile, undergoes no alteration in air, and resists the action of acids.

Where is it found?—Platinum is found in alluvial districts, in the debris of the earliest volcanic rocks, on the slopes of the Ural mountains in Russia, in Brazil, Santo Domingo, Borneo, Ceylon, California, British Columbia, and Australia. It is generally found in sands like gold obtained from what are termed placer diggings. Although almost always in small grains, it has been found in masses of considerable size. The largest mass ever found weighs twenty-one pounds troy, and is in the Demidoff gallery. The grain of native platinum usually contains from 75 to 85 per cent. of pure metal. It is generally found in rounded grains, like placer gold, and sometimes crystalized in octahedrons.

Does it effect the line to move the armature lever back and forth with the finger?—No; as the lever is not connected with the main line, it only serves as the key to operate the sounder.

What is the standard resistance of the relay used for ordinary lines?—150 ohms.

What should be the resistance of all the relays on a line to give the best results?—Their combined resistance should equal the resistance of the line and battery.

Should instruments of different resistance be used on the same line?—No; every instrument in the same circuit should have the same resistance.

Are all relays made similar to the one herein described?—No; they differ somewhat in form, though the principle is the same. However, another form of relay, called the Siemen's "polarized relay," is much used in Europe, and to some extent in this country, on special systems.

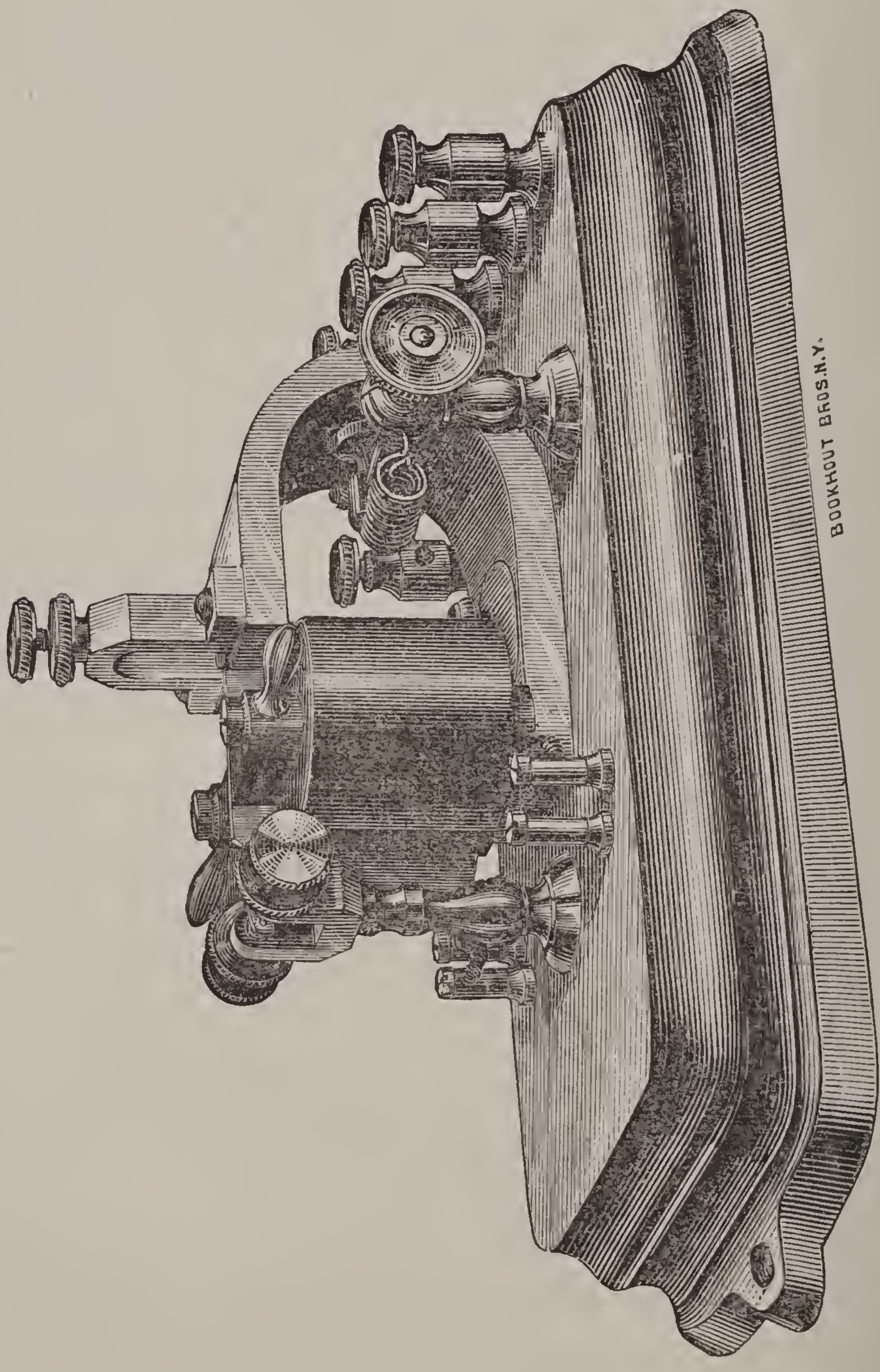


Fig. 11.—The Siemen's Polarized Relay.

What is the polarized relay?—The polarized relay is regarded as an improvement on the ordinary Morse relay, particularly as it does not require any adjustable spring as a retractile force, and on this account is exceedingly sensitive, the armature being either a permanent magnet or is inductively magnetized by permanent magnets. Its essential parts consist of a steel magnet bent to a right angle—one end being a north pole and the other a south pole. On the end that lies flat, soft iron cores and the wire coils or helices of an upright electro-magnet are fixed, whilst at the extreme end of the upright part of the steel magnet, a soft iron bar is pivoted, which operates as the relay lever and armature, turning horizontally on its pivot, the motion of the lever being limited by a metallic screw on one side and by an agate stud on the other. Fig 11 shows the Siemen's polarized relay with improved swivel adjustments.

SECTION XXV.

THE REGISTER AND SOUNDER.

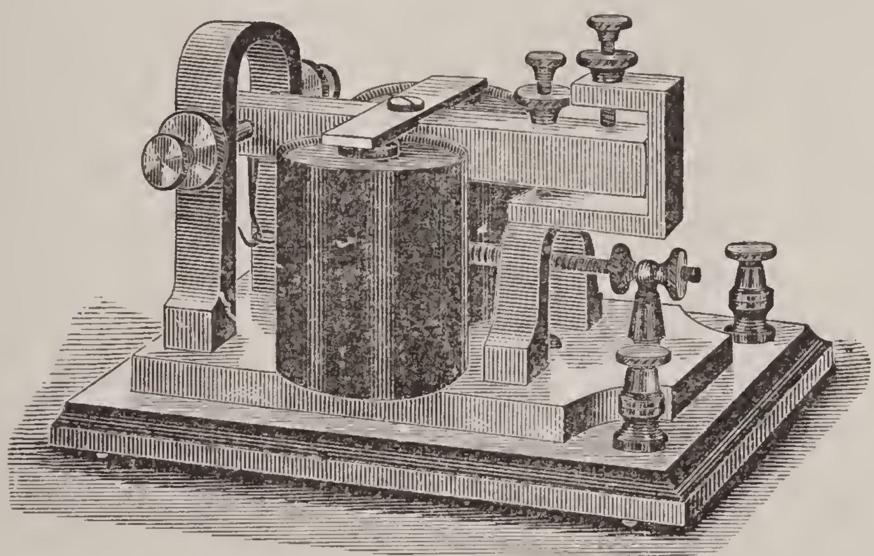


Fig. 12.—The Sounder.

What instruments are employed in receiving messages?—The register and sounder.

Wherein do they differ?—In the fact that the former, provided with clock work and recording apparatus, records the messages upon slips of paper, while the latter does not, the click of the instrument indicating the message to the ear of the operator.

What are the essential parts of the sounder?—Two upright electro-magnets and a soft iron armature attached to a movable lever situated near the ends of the soft iron cores. See Fig. 12.

How is the distance regulated through which the armature lever moves?—By two adjustable screws, one of them checking the movement toward the magnet, and the other limiting the reverse movement.

Should the armature be brought into contact with the poles of the magnet?—The same truth applies to the sounder magnet and its armature as in the relay; the armature must never come so near the poles of the magnet that one thickness of ordinary writing paper will not pass between them.

What else is necessary to regulate the movement of the armature?—A light spiral spring attached to the armature, which must be adjusted so that the current will overcome the force of the spring, or, in other words, adjusted in proportion to the strength of the current. If drawn too tightly, it will not allow the armature to respond to the attraction of the magnet. It should only be set at sufficient tension to raise the lever sharply back against its top limit screw when no current is passing through the magnets. When the sounder is once adjusted and gives a satisfactory sound it should be *let alone.* If the sounder has always worked well, but at length gives some indications of residual magnetism in the cores, reverse the wires.

In what respects besides those already mentioned do the register and sounder resemble the relay?—In them as in the relay, the armature must be kept from contact with the electro-magnets, in order to avoid the effects of residual magnetism; also, an ad-

juster is necessary in each instrument to regulate the tension of the spring attached to the armature lever.

What is the standard resistance of the sounder?—4 ohms.

Are all sounders made alike?—They are made in a variety of forms (the principle, however, being the same) the kind employed in any particular case depending upon circumstances. Some operators can distinguish a light sound more clearly than a heavier one, and *vice versa.*

Should the sounder be screwed down to the table?—Yes; as the acoustic vibrations are thus communicated to the latter, which acts as a sounding-board and thence to the ear.

What are the advantages of operating by sound?—There is less difficulty in adjusting the instrument, and business is done more rapidly and with less liability to error.

NOTE.—The operation of the register is not explained, as it is not now in general use, having been superseded by the sounder.

SECTION XXVI.

THE BOX RELAY OR MAIN LINE SOUNDER.

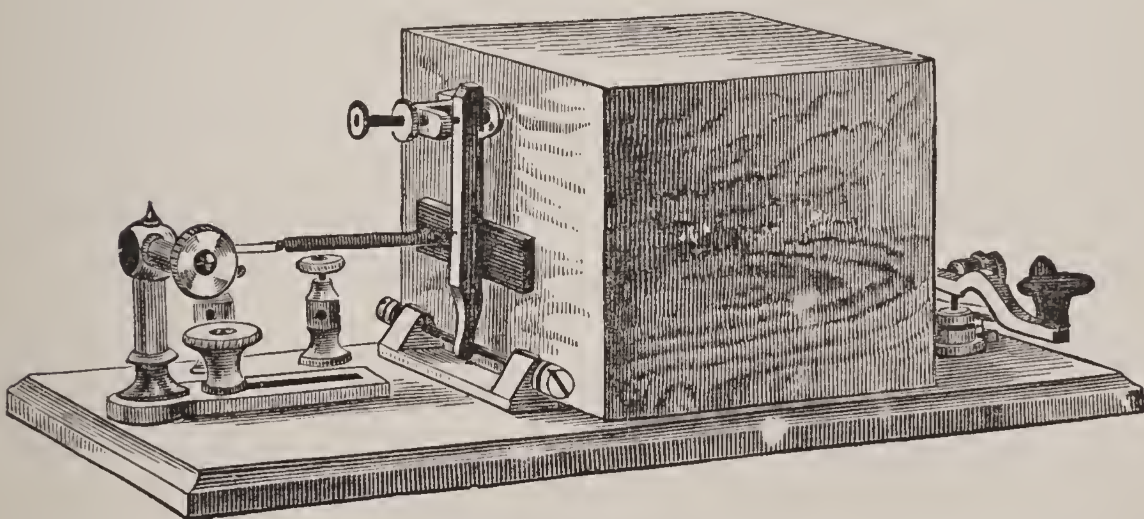


Fig. 13.—Box Sounding Relay and Key.—Combination Set.

What is the box relay or main line sounder?—An instrument worked direct by the main line current similar to the relay (often with a key attached) for increasing the sound of the armature, thus dispensing with the local circuit. (See Fig. 13.)

How does it differ from the ordinary relay?—In having a more powerful electro-magnet, and the sound increased by allowing the armature lever to strike upon the screw-point attached to the wooden box which encloses the magnets.

Can this instrument be substituted for an ordinary relay?—Yes; when having local circuit connections.

What is the pocket relay or small main line sounder?—A small relay or main line sounder constructed in a convenient and compact form, with a key attached, the whole arrangement placed in a small hard rubber case convenient to carry in the pocket.

What are these portable instruments used for?—They are much used by line repairers, and operators in the military service, and also in the railway telegraph service for establishing a temporary office at points where the track has been obstructed by accident.

What contrivances besides the essential parts named belong to the instruments previously described?—Screws for regulating the play and bearings of movable parts, and binding screws to receive the circuit wires, connecting with the movable parts by wires running beneath the base.

How many of the latter has each instrument?—Two, excepting the relay, which has four, because it connects with two circuits.

SECTION XXVII.

ARRANGEMENT OF THE MORSE APPARATUS — ADJUSTMENT AND CARE OF THE INSTRUMENTS.

What is the arrangement of the Morse apparatus in an office? —The apparatus comprising sounder or register, relay, key, switch, local battery and connections, are conveniently arranged as follows: A table having been provided for the purpose, the sounder or register is placed in the center, the key on the right, and the relay on the left, at the rear of the table. The switch or cut-out (see Section XXXII.) is secured in an upright position on the wall or any convenient location. The key is fixed in position by boring holes through the table for its legs; holes are also bored through the table near the binding screws of the relay and sounder, for the connecting wires.

How are the instruments connected in circuit?—The line wires are extended into the office by means of insulated copper leading-in wires, which are led to the proper binding screws, usually at the top of the switch. At a terminal office, however, only one wire comes in for each line, thence from the switch to the main battery and ground. From the switch one of the instrument wires is led to one leg of the key and secured, and the other to one of the relay binding screws, which is usually at the right hand end of the relay. The main circuit is then completed by running a short wire from the remaining right hand relay binding screw to the other leg of the key. The order of the connections is indifferent. The local battery, usually consisting of two cells, should be placed not too far from the instrument in a dry and warm location convenient of access, in a box or on a shelf of a closet. After setting up a local battery run a covered wire from one of the binding screws of the sounder to one

pole of the battery, then another wire from the other pole of the battery to one of the left hand binding screws of the relay, and from the remaining binding screw of the relay to the remaining binding screw of the sounder, thus completing the local circuit. The order of the connections is indifferent in this circuit also. Care must be taken, however, to properly connect together the battery cells, and also to bare the ends of the covered wire wherever a connection is made in either circuit.

What is the arrangement of the apparatus in large offices?—In most of the large offices the different sets of apparatus are placed in groups of four upon "quartette tables," that is tables conveniently arranged for four sets of instruments, each section separated from the other by a low plate glass partition or screen. A group of four pairs of instrument wires extend from the switch to each table and a second group of four pairs of local wires extend from each table to a group of four distinct local batteries in the battery room. These wires are insulated, and either laid up in cables bound with tarred tape, or placed in proper shape beneath the floor.

How many offices can be operated in the same circuit?—As many as thirty or forty intermediate offices are sometimes operated in this manner on a single circuit, but twenty or thirty instruments is probably as many as should be placed in a single circuit to work advantageously.

ADJUSTMENT AND THE CARE OF INSTRUMENTS.

What is the most important duty connected with the management of instruments?—Adjusting the relay.

What is meant by adjusting the relay?—Tempering the spring connected to the armature according to the strength of, and variation in the current. In most of instruments the magnet itself can also be moved forward and backward by a screw, thus adjusting its position to that of the armature according to the strength of the current, a strong current requiring the magnet to

be drawn farther away from the armature, and a feeble current the reverse.

What are the terms applied to adjusting?—*High* and *low* adjustment according to the strength of the current, a strong current requiring a tightening of the spring, high adjustment and a weak current the reverse.

Under what circumstances is adjusting the most difficult and perplexing?—In wet or damp weather, especially during thunderstorms. Variations in the current constantly occur, and when a line is imperfectly insulated, or in case of a cross, or when an escape is a swinging one, that is, when a wire keeps swinging against another or against a tree, or other conductor, but remaining in contact only a short time, sometimes the slightest variation from a certain point in either direction will cause the instrument to cease working, and require very careful adjustment; under such circumstances, the operator is frequently required to keep hold of the screw regulating the spring, turning first one way and then the other nearly all the time he is either sending or receiving,

If a telegraph line was perfectly insulated, or in the case of dry, cold weather, would this change in adjustment be necessary?—No; as the strength of the current would be the same at the most distant point from the battery that it is at a point close to it. In short, it would be the same at every point in the circuit.

In wet and damp weather what point on a line is the current the strongest?—Near the battery, because a considerable portion of the current leaks over the insulators and through the poles, and returns to the battery without traversing the entire line. This explains why the armature is adjusted farther from the magnet in wet weather and on long lines. When the distant operator opens his key there is still considerable current from the battery going out through the relay and returning over the wet insulators and through the poles along the line. By setting the

armature so far off that the partial current will not work it, the signals when the distant operator closes his key are superposed upon this current, as it were, and are easily received.

Does adjusting the relay in one office have any influence upon the instruments in other offices?—No, as the armature lever is not connected with the main line.

Is the local circuit subject to the fluctuations of the main line?—No. The local battery simply grows weak by use when it has to be renewed. The spring on the arm of the local (sounder) magnet merely requires weakening, as the battery working it becomes exhausted.

When there is trouble on the local circuit, how may an operator know that it exists on the local instead of the main?—By the failure of the sounder to respond freely in unison with the lever of the relay, when that lever is moved back and forth with the finger.

What should always be done before opening a key?—Operators should never open the key without first turning the relay adjusting spring high enough to break the local circuit, in order to make sure that no one else is using the line: and on calling another office, to have the relay so adjusted as to receive the response. It is well to keep adjusted for the most distant office in wet weather.

What instrument may be used to advantage?—The galvanoscope, or small ordinary compass. When placed upon the relay helices the slightest current may be detected.

"When the line is being worked, the needle of the compass is agitated, and when the circuit is closed or open it remains perfectly quiet. An operator noticing the agitation of the needle, even if there was not sufficient tension upon the armature of the relay to cause it to respond, would be aware that some office was using the line, and thus avoid breaking in unnecessarily."

What is the duty of operators in regard to binding screws in in-

struments and switches?—They should be examined and tightened up daily, as they are liable to loosen by the warping of the wood, jar of passing trains, etc. Instruments should be covered at night and kept free from dust.

SECTION XXVIII.

THE REPEATER.

What is the repeater?—It is an instrument designed to transfer a message directly from one circuit to another, thus avoiding the necessity of its being re-written by an operator.

How does it connect the circuits upon which it is employed?—It establishes between them a mechanical connection of such a nature that one circuit by opening and closing opens and closes the other automatically, upon the same principle that the relay operates the local. If there is sufficient power to deflect a magnetic needle in a perceptible degree on one line this can be made to open and close a circuit by which a fresh, powerful current will be set in motion on another.

Does it cause any communication of electricity between the two circuits?—It does not.

Why is it necessary to use the repeater?—Owing to the resistance and defects of insulation, it is found impossible to work very long lines during all states of our variable weather, therefore shorter circuits have been resorted to, and when it is desired to work the lines through to places beyond the limits of a single circuit, it is done by means of an arrangement known as the "button repeater," or the peculiar arrangement of instruments and circuits, often very complicated in its structure, known as the "automatic repeater." When employed in an office entered by several lines, it is so arranged with switches as to connect any two lines desired.

For what other purpose is the repeater used?—It is used to connect a number of branch lines with the main line for the purpose of transmitting press and market reports to several places simultaneously. All stations in connection are thus enabled to communicate with each other as readily as if situated upon the same circuit.

Explain the arrangement of the "button repeater."—The arrangement known as Wood's "button repeater" is probably the one most generally used, the operation of which is controlled by a simple double action switch or button, and consequently needs the constant attention of an attendant, as it can only be worked from one direction and from the other, by turning the switch. The armature levers of the sounders on both lines are provided with platinum contact points, similar to the relay, so that the lever on each sounder forms in effect a key for opening and closing the circuit of the other line. These circuits being in connection with the switch, the signal of one line is transferred to the other and *vice versa*, at pleasure, by merely changing the position of the switch. When either sounder fails to work co-incident with the other, the button should be instantly turned, thus permitting the receiver to break, or become in his turn the sender. When it is desired to connect the two circuits into one through circuit, it is only necessary to open the ground switch, thus throwing off the ground connection.

Edison's "button repeater" is probably the most simple arrangement of connections and apparatus, as only the ordinary office instruments and an ordinary two point ground switch is required. To set it up, the line, say from the west, is connected first with its own relay; thence it passes to one of the points of the ground switch, and through the opposite relay points to ground. The other line is similarly connected; the main post of the ground switch is then connected with one pole of the local battery; the other pole of the local battery connects with the sounder, passing from the second binding screw of the

sounder to the wire which connects the two sets of relay points with the ground. The sounder and local battery form a portion of both local and main circuits.

When the button switch is turned on to the point which touches the eastern circuit, the eastern circuit repeats into the western, while the western relay works the sounder, and *vice versa.*

NOTE.—The above description of Edison's "button repeater" may be found in "Lockwood's Notes and Queries," and also in "Pope's Modern Practice," and a description and diagram in "Davis and Rae's" excellent and most valuable handbook of electrical diagrams and connections of all the various repeaters in use at the present time.

What automatic repeaters are now most generally used?—The Milliken automatic repeater, invented by G. F. Milliken, of Boston, is probably much more used at the present day than any other, having been adopted by the Western Union Telegraph Company as their standard. The others used to some considerable extent are the "Toyes," "Haskins," "Bunnell," and the "Smith."

Explain the principle and arrangement of the Milliken repeater.—The principle of this repeater is, that by a novel arrangement or application of the auxiliary local magnet, first introduced by Clark, and placed above and in front of the relay magnets, the armature lever of which, when drawn back by its spring against the lever of the relay with which it is placed in mechanical combination, prevents the movement of the latter, when the main circuit through the relay is broken. The adjustment of these auxiliary local magnets, and of their armature springs being entirely independent from that of the relays, it is only necessary that such springs be actually and relatively stronger than those of the relays with which they are mechanically combined. By this means "false breaks," arising from any required tension of the relay springs on the receiving side of the repeater are effectually prevented. The relays are placed in the main circuits, which connect the batteries and earth, and through

the repeating points of the opposite sounders respectively. The local sounder magnets are each operated by the relay on the same side; the auxiliary local magnets are operated respectively by the movement of the opposite sounder levers. If either relay makes a false break, or "kicks" when the opposite side is writing, pull upon the spring of the extra local armature. Experience, however, shows that the armatures of the auxiliary local magnets need adjustment but seldom, if the local batteries are in good working condition. The relays of the repeater are managed in exactly the same manner as an ordinary relay. The sounder levers should have about the usual amount of play, but the tension of the retracting springs of the sounders should be very moderate, only a little more than enough to raise the armature when released by the magnet. When working most efficiently the apparatus usually has what may be termed a dragging sound. If the relays are properly adjusted the opposite side will always be able to break without difficulty, especially if the circuit is opened for about two seconds, as it should be, by the receiving operator.—*Prescott's Electricity and the Electric Telegraph.*

In the operations of repeaters what precautions should be observed?—In working through one or more repeaters the sending must be very firm, and the dots, dashes, and spaces made *much longer* than under ordinary circumstances. The relays should be very carefully adjusted, and the repeater levers adjusted to have as little motion as possible in order that the signals may go through more firmly.

SECTION XXIX.

THE DUPLEX.

The several methods of multiple transmission may properly be said to be an outgrowth of the invention in 1850, of Dr. Wilhelm Gentl, director of the Austrian State Telegraphs, whose invention was immediately followed by the improved methods of Treschen, of Hanover, Germany, and Siemens-Halske, of Berlin, Prussia; but as the system did not seem advantageous at that day, and upon the short lines then used, it fell into disuse; and it was not until 1872, when the improvements on the Siemens-Halske system was accomplished by Mr. Joseph Stearns, of Boston, that a satisfactory system of duplex telegraphy was generally adopted, which was then placed in operation upon many of the most important lines in the United States, that has within the past few years proved of so much value in practical telegraphy.

Name the different methods of multiple transmission.—The "duplex" and "quadruplex" methods. All other methods of multiple transmission may be embraced in the term "multiplex telegraphy."

What is duplex telegraphy?—The method of multiple transmission, by which the capacity of a single wire is doubled, enabling messages to be sent in opposite directions at the same time, without interference.

What principle is duplex telegraphy based upon?—It is based upon the fact, that currents of electricity invariably divide themselves through any number of paths that are left open to them exactly in proportion to the resistance which the wire offers to the current, and by taking advantage of this fact, the effect upon

a magnet can be so equalized as to produce a complete neutrality, thus the currents, flowing in opposite directions, are made to neutralize each other, and it is this neutralization that is made use of in duplex telegraphy.

How many ways are there of working duplex?—Two, the differential and the bridge method. Many inventions of duplex telegraphy have, however, been produced from time to time, each possessing special features of merit, and are more or less used, but the majority of those in use at the present time operate on the differential principle.

The duplex system, in some form, is now in general use in nearly every country in the world, and its use on submarine lines has been quite successful.

What conditions are necessary to the successful working of duplex telegraphy?—"The receiving instrument must be so connected to the line and to the earth, that it shall remain entirely unaffected by the movements of the transmitting key at the home station, while at the same time it will respond to every movement of the key at the distant station."

What apparatus is required in the operation of Stearns' differential method?—In adapting the duplex method to the practical requirements of the telegraphic service, some modifications in the ordinary apparatus are required. The relay used, termed the "differential relay," has its helices wound in opposite directions with two wires of the same resistance and of equal numbers of convolutions, so that when equal currents pass through them they will exert an equal and opposite magnetic effect upon the cores, and thereby neutralize each other. The sending sounder, known as the "transmitter," is provided with a metallic bracket on the extremity of the lever, and also on the same end a flat spring mounted with an insulating support, so arranged as to come in contact with the bracket when the lever is depressed, and in contact with a screw supported by a standard, when the lever is elevated, and an armature near the other end of the lever, actuated by an electro-magnet, local battery, and an

ordinary key, so arranged as to be in contact with battery when the lever is depressed and with *ground* when elevated ; one contact always taking place through the spring contrivance before the other ceases. Thus the line is never opened but always on battery or ground. The transmitter is also made to act as a sounder so that the American operator hears the accustomed accompaniment of his own sounder when transmitting. The ordinary Morse receiving sounder is used, connected with the relay and operated by a local battery in the usual manner. A rheostat and condenser (see Section XXXIII.) is also used in connection with the apparatus, and a resistance, termed a "spark coil," is inserted when a battery of small internal resistance is used. A switch conveniently arranged is also used in connection with the apparatus to change the connections from duplex to ordinary working.

In duplex telegraphy what is the object of the rheostat?—To equalize or regulate the resistance of the artificial line to that of the main line, including the battery and one wire of the relay at the distant office.

What is the object of the condenser?—To balance or neutralize the effect of the return charge, arising from static induction on long lines, or when working through a submarine cable, or underground wire, which is found to produce a "kick" or false signal the moment battery contact is made or broken, which seriously interferes with the operation of the instrument. In order to regulate the charge by means of the rheostat, the condenser is attached by a wire to a brass plate on the former, which is provided with holes for plugs to connect it with the resistance coil plates, whereby the condenser charge can be sent through any portion of the resistance coils as desired.

Static discharge can be entirely compensated by the use of an induction coil, or a series of electro-magnets, instead of the condenser.—*Culley.*

Explain the arrangement of the differential method.—The principle and general arrangement does not differ materially from that

of Frischen, except that the position of the Morse key in the circuit is replaced by the transmitter. The differential relay is placed in circuit by connecting the outer end of one of the magnet wires, to the line wire, and connecting the inner end of the other wire to one terminal of the rheostat, the other terminal of which is to earth. The remaining two wires of the relay are joined together, and connected to the spring which is carried by, but insulated from the lever of the transmitter; this lever is connected to earth by a wire in which is placed a resistance equal to that of the battery. When the key is open the spring and lever are in contact, and together form a part of the circuit from the line to the earth. One pole of the battery is connected through a standard to the contact screw of the transmitter, and the other to earth. One pole of the condenser is usually connected to the wire joining the relay and the rheostat, while the other pole is to earth. The apparatus is placed on a table conveniently arranged for the purpose, or on tables opposite each other or side by side, the transmitter and sending key on one table, and on the other the receiving apparatus, including the rheostat, condenser, and an extra key in the local circuit operating the transmitter. The batteries are generally connected, so that when both keys are closed at the same time, the currents move in the same direction and assist each other, but opposed batteries may be used.

Describe the operation of Stearns' differential method.—The apparatus should first be adjusted in proportion to the line resistance, by removing the plugs in the resistance coils until the resistance of the coils equals the resistance of the line. When they are equal the armature of the relay will not be affected by the working of the transmitter sounder. If the signals received are too light, the resistance of the rheostat must be increased; if too heavy, the resistance decreased. If now the key at the home office be depressed, the circuit of the local battery will be closed, and the armature of the transmitter at-

tracted, thereby moving the opposite end of the lever so as to bring the spring in contact with the screw after removing it from its previous contact with the bracket, on the extremity of the lever. Thus the line is transferred from earth to the battery or *vice versa* without interrupting the circuit. When the key is depressed the current from the battery passes through the contact screw and spring to the junction of the two relay wires, where it divides into two equal portions, one-half of it going through one wire of the relay to and over the line to the distant office, thence through one wire of the relay to the junction of the two relay wires, thence through the spring lever and resistance coil to earth. The other portion of the current passing from the junction in an opposite direction through the other wire of the relay, and thence through the rheostat to earth. The relay being thus acted upon simultaneously by equal and opposing currents, will remain entirely unaffected. The distant relay, however, will be affected by the current passing over the line, and through one only of its wires to the earth, and will produce signals corresponding to the movements of the key at the home office.

Should the key at the distant office be depressed, a similar action takes place, the current passing from the battery through the contact screw and spring of the transmitter, to the junction of the relay wires, where it divides, one-half passing through one wire of the relay and over the line, combining with the current from the home office, and the other half returning to the earth through the other wire of the relay and rheostat, thus each relay is unaffected by the current from the battery at its own office, but responds to the current from the battery at the other office. Whatever may be the position of the key or transmitter lever at either office, the resistance presented both to the outgoing and incoming currents at each office must be the same, hence resistance coils are placed in the wires connecting the

levers with the earth, and their resistance made equal to that of the batteries at their respective offices.

When the condenser has an electro-static capacity greater than that of the line wire, how may its effect upon the relay be reduced?—By including a portion of the resistance of the compensating circuit between the relay and the point at which the condenser is attached to the rheostat. The latter being so arranged as to afford a ready means of connecting the condenser between any two coils. In making up the necessary resistance in any case, as many as possible of the low numbers should be interposed between the relay and the point where the condenser is connected.

How may a condenser of much smaller capacity than the line be used?—By inserting a resistance between the relay and the line, the resistance of the compensating circuit being correspondingly increased, and the condenser connected close to the relay. If the resistance is made considerable, the battery power may be increased, which will cause the condenser to take a higher charge.

What apparatus is required in the operation of Stearns' bridge method?—This method permits the use of the *ordinary apparatus* arranged in combination with the "transmitter" resistance coils, "rheostat," and a suitably arranged condenser.

What is the principle upon which this method is constructed and operated?—It is based upon the principle of the Wheatstone bridge or balance, that when a current is divided between two circuits, which are connected by a cross wire or bridge, no current will pass through the bridge, provided the resistance of the opposite circuits on each side are equal, or are in the same ratio to each other.

Describe the arrangement of the bridge method.—In this method the arrangement of circuits is such that the relay is placed in the bridge or cross wire of the Wheatstone bridge or balance.

The line, together with the earth, constitutes one side of the balance, the rheostat and condenser the opposite side, and the two branch circuits in which are placed adjustable resistances the other side.

Describe the operation of the bridge method.—The action of the arrangement is similar to that of the differential. Neither instrument is affected by outgoing currents, so long as the resistances of the line and artificial resistances are equal. The battery is connected through the transmitter to the point where the circuits diverge, forming the two arms of the balance, the outgoing current dividing, one half going through the resistance coil of one arm, thence to and through the rheostat to earth. The other half going through the resistance coil of the other arm of the balance, thence over the line to the distant office, where it divides, one portion going through the bridge wire and relay, thence through the resistance coil of one arm and by the spring and lever of the transmitter and resistance coil to earth; the other portion going through the resistance coil of the other arm, where it joins that portion of the current passing through the receiving instrument, thence to earth, as already described. Thus when a current is transmitted from the home office, it passes directly to the line, without passing through the receiving instrument at that office, this instrument or relay responding only to the currents transmitted from the distant office. The condenser is connected with the rheostat as in the "differential" and used for the same purpose.

Which method of duplex is preferred, the differential or bridge?—Although the bridge method has the advantage of being worked with no alternation of ordinary apparatus, and is less liable to injury by lightning, the resistances more quickly and easily adjusted, and the neutralizing effect of the condenser upon the relay, more conveniently adjustable to the varying conditions of the line, yet the "differential" method is preferable for

long circuits, as it gives a stronger working current. However, the bridge method is preferable on short lines of low resistance, especially where batteries with low internal resistances are used.

If the line or cable be of considerable length it will receive and give up its charge more slowly than the condensers, and to make the discharge equal in duration as well as amount, resistance should be introduced between the condenser and the branch circuit.

Can the duplex method be arranged as a repeater?—Yes.

What is the arrangement of the duplex repeater?—The Stearns differential method is more generally used. The repeating being done by the relays. The only modification necessary is to connect the local circuit of the relays and receiving sounders, to the magnets of the opposite transmitters, which may be done by means of a switch arranged for the purpose.

SECTION XXX.

THE QUADRUPLEX.

The quadruplex method has been brought to great perfection in this country, and the use of the duplex method described in the previous section has been largely superseded by the quadruplex.

What is quadruplex telegraphy?—The facility of transmitting four messages on one wire in contrary directions.

Explain the principle of quadruplex telegraphy?—The principle consists in combining together two distinct and unlike methods of single transmission in such a manner that they may be carried on independently upon the same wire and at the same time, without interfering with each other, viz: In working one apparatus with reverse currents, independent of their strength, and the other apparatus, with strong currents independent of their direction, the two distinct qualities of the current, polarity

and strength being utilized, forming a practical system of simultaneous transmission in the same direction, capable of being duplexed. The application of one or more of the existing duplex combinations in use, forming the quadruplex apparatus, applicable to long lines, hence it is, in fact, a double duplex system.

What important practical advantage does this method possess?—The action of the two receiving relays are perfectly independent of each other. They actuate different sounders, and are separately under the control of their own receiving operator, who can thus adjust to suit himself, thus making it practically possible to transmit four messages at the same time on a single wire. Any of the different methods of simultaneous transmission in opposite directions in use may be applied to it, as a practical system of quadruplex transmission. Although the bridge method was employed with the earlier combined systems, as being best adapted to the conditions necessary for success, the differential is now more generally employed.

When and by whom was the quadruplex system devised?—In the summer of 1874, by Mr. Thomas Edison, while engaged in conjunction with Mr. George Prescott, electrician of the Western Union Telegraph company at New York, in experimenting on the Stearns duplex apparatus, with a view of introducing certain modifications and improvements.

To whom is due the present perfection of the apparatus?—To Mr. Gerrett Smith, the assistant electrician of the Western Union Telegraph company, who, by his labor and inventive genius, has introduced nearly, if not quite all, of the improvements and modifications from the original Edison-Prescott quadruplex, which has so much increased its usefulness.

Describe the mechanical and electrical construction of the quadruplex apparatus.—In the improved system of quadruplex the differential method is in general employed throughout, instead of the bridge. The apparatus is placed in position on a quartette

table, so arranged that the senders occupy the left, and the receivers the right, opposite each other.

Keys.—Two ordinary keys are placed in the proper local circuit, which operate their respective transmitter, four keys in all, the two extra ones for the use of the receiving operators to break or ask for corrections, the senders knowing when they are so used by their transmitting relay failing to respond to the key.

The improved double current transmitter, or pole changer.—This apparatus, which reverses the direction of the currents, is extremely simple and yet capable of the most accurate adjustments, so that the current of one polarity does not cease until that of the opposite polarity commences.

The lever of the transmitter is connected with the earth. The pole changing apparatus is situated at the extreme end of the lever, supported by a post, and consists of two insulated contact springs in connection with the zinc and copper poles of the main battery respectively. The play of the spring is limited by two contact screws which are in connection with the line through the post that supports them. To insure successful working the transmitter should be carefully adjusted. In its vibration the lever should touch one of the springs at the same instant that it leaves the other. If the springs are adjusted too far apart there will be a break in the circuit as the lever will break contact with one spring before it touches the other. If too near together the battery will be placed on short circuit too long from one contact being made before the other is broken.

The single current transmitter.—For altering the strengths of the current is the same as employed in the Stearns duplex. The play of the lever should be about one thirty-second of an inch between the limiting stops and the contact screws, in order to work well.

The compound polarized relay.—Used to respond to the strength of the current whatever their direction, consists of two

single coil electro-magnets wound differentially to a resistance of about 200 ohms, arranged with their poles facing each other upon opposite sides of a polarized armature. Two screw stops regulate the distance of the play of the armature and limit the movement of the crank levers in one direction, while two others limit it in the other direction. When the tongue of the armature is in its position of rest it is in contact with both the levers, completing the local circuit by putting the local battery on short circuit, but when the armature is moved by a current in either direction then the short circuit is broken and the current from the local battery passes through the coils of the sounder and works it. Thus at all times, when the entire force of the batteries is on the line, its local circuit is opened by the armature being drawn toward and coming in contact with either one or the other crank levers, in either case opening the local circuit and working the sounder by *opening*, instead of completing, the local circuit. When, by the depression of the proper key, the battery current on the line is decreased or withdrawn, the armature will remain in the center in contact with both the crank levers closing the sounder circuit. Thus the circuit is closed only when a weak current, or no current, is on the line, and broken when a strong current is sent. On circuits exceeding two hundred miles in length the sounder is best operated through the medium of a local relay or repeating sounder, in connection with the compound relay, which should be adjusted as close as an ordinary relay.

Adjustment.—The compound relay is the most delicate part of the apparatus and requires the most skill in adjusting. The electro-magnets should be adjusted by means of the check nuts at the back so that their poles are at equal distances from the opposite faces of the polarized armature. The play allowed the contact levers may be considerably less than that of an ordinary relay and the proper tension of the springs depends upon the condition of the line current.

The single polarized relay.—Used to respond to the changes in the current, is a simple polarized relay of the Siemen's pattern, but fitted with a perfectly rigid tubular tongue, and wound differentially, each wire having a resistance of about four hundred ohms, and responds only to the working of the double current transmitter, and not acted on by the alteration of the strength of the current. Its rigid tongue makes it work equally well with every current, whatever its strength. This relay should be adjusted with a play about the same as that of the ordinary Morse relay.

The main battery.—Is divided into two divisions, one having about three times the cells of the other. There is no rule as regards pole to line, as it is a matter of indifference.

Resistances.—The following resistances are used: A large Rheostat for balancing the resistance of the line. A resistance for compensating resistance of the large division of the battery. A resistance for compensating the resistances of the entire main battery thrown in by a switch when the line is put to earth for adjustment on starting to work. A fourth series of coils is also used as a *spark coil* to reduce the effect of the sparks from the whole battery, which might otherwise fuse the contact points.

Condensers.—Are used for the same purpose as employed in duplex working, *i. e.*, for compensating the static charge on the line.

On lines of over 500 miles a condenser is also inserted between the line and compensation wire of the relays for the purpose of bridging over the interval necessary for the current to acquire a sufficient difference of potential.

Quadruplex repeater.—"The arrangement for repeating is very simple in principle, and consists in placing the two transmitters of one line in the same local circuits with the corresponding receiving sounders of the other line. Thus the quadruplex system" is capable of considerable extension and variation. It

works to distances exceeding 1,000 miles by means of repeaters fixed about the center of the circuit. Thus New York works to St. Louis with repeaters in at Pittsburg, and to Chicago with repeaters in at Buffalo.

Quadruplex working is applied to the type printing instruments as well as to the Morse system. When thus applied, however, two sides are used for breaking and the exchange of service signals, or for carrying on two separate communications by the Morse system.

Can the Morse system be arranged to work duplex and quadruplex?—Yes; many of the Morse instruments in the principal offices *are arranged* to be worked on the duplex and quadruplex systems, as well as in the ordinary way.

What term is applied to the quadruplex apparatus?—Quad.

Is it possible to send more than four messages in opposite directions on a single wire?—In multiple telegraphy the difficulties increase as the cube of the number of transmissions are sought. However, Mr. Patrick B. Delany, of New York City, has invented an ingenious system, called the "Delany Synchronous-Multiplex System," founded on the Phonic Wheel of Poul La Cour, of Copenhagen, an electric motor, driven by the pulsations of an automatic circuit breaker. This motor forms a very important part of the multiplex system, as it divides the line into a number of different circuits. By this system it is possible to transmit simultaneously, over a single wire, a great number of messages, either in the same or in opposite directions. This is accomplished by the synchronous rotation of two discs placed one at each end of the line, by means of which a single wire constituting the line is simultaneously connected, at both of its ends, to corresponding operating instruments, and transferred from one set of instruments to another so rapidly that the operators, either sending or receiving, cannot realize that the line has been disconnected from their instruments and given to others, because each of them will always have the line ready for use even at the highest rate of manipulation, and will, therefore, to all practical intents and purposes, have at his disposal a private wire between himself and the operator with whom he is in communication. By this system, with the use of an ordinary printing telegraphic instrument, as many as seventy-two independent and separate circuits have been applied to a single line, permitting of seventy-two messages being sent at the same time, but at the rate of only about three words per minute for each of the seventy-two circuits. With the use of six Morse telegraphic circuits the most rapid rate of transmission attainable by the most expert operators is practicable; and with twelve Morse circuits a rate of transmission is practicable as rapid as that generally employed by an ordinary operator.

SECTION XXXI.

THE GRAY HARMONIC SYSTEM.

The application of harmonics to telegraphy is the invention of Prof. Elisha Gray, of Highland Park, Illinois, and is based upon the familiar principle of acoustics, that a solid body having a musical note will vibrate by sympathy when in contact with another body having the same note. The principle adopted by Prof. Helmholtz, of Germany, in his method of separating tones transmitted through the air, is that on which is based the method finally adopted by Mr. Gray after numerous experiments which demonstrated certain facts, partly known previously to students of acoustics, and partly established by the experiments of Mr. Gray. These are that sounds travel in waves; that sound waves are of different lengths, each tone having its own length of wave; that different waves of sound may be transmitted simultaneously on a single wire. Every transmitting machine, therefore, has its distinct, particular tone, attuned perfectly by a tuner, and the message it transmits will travel along the wire without interrupiton by or interference with another message sent in a different tone, until it reaches a receiving instrument tuned to exactly the same pitch as the transmitting instrument.

By separating the instruments at each end of the line by non-conducting partitions, and varying the period or length of the tones, it is easy to conceive that two or four or six different messages may be sent over the same wire at one time, each pitched, so to speak, on a different key, corresponding to the different tones of the gamut.

On long lines the successful working of this system depends much on the conductivity of the wire, and its insulation. The Postal Telegraph Company have adopted the Gray harmonic system and overcome much of the resistance by using a heavy

compound wire composed of a steel core, copper plated, the copper weighing 500 pounds to the mile, and the steel 200. The splices are riveted together by metal plates filled in with solder, thus this wire combines strength and great conductivity.

Describe the Gray harmonic system of multiple telegraphy?— "At the sending end of the wire a reed is sent into vibration, and each of its swings is made to send a wave of electricity over the wire. These waves, reaching the receiving end, pass around the cores of an ordinary electro-magnet which has for an armature another reed with the same fundamental tone as the first one. Each pulsation of current magnetizes the soft iron core, which, in turn, attracts the reed and draws it out of place; then the current is broken, the core is demagnetized, and the reed, being set free, flies back to, and on account of its elasticity, a little beyond its position of rest, when it is again attracted by another wave of current and the motion repeats itself as long as the current waves last. If the vibrator at the sending end be thrown in and out of circuit, the reed at the receiving end will start and stop exactly in accordance with it, and telegraphic signals may be transmitted, being received in the form of musical notes, a short note forming a dot and a long one a dash."

How are the musical notes reduced into Morse characters upon an ordinary sounder?—"A very ingenious device has been invented by Professor Gray to reduce the notes again into Morse characters upon an ordinary sounder. A small bar of metal, called a rider, is balanced upon a supporting piece, and has one end resting upon the receiving reed. A light adjusting spring is attached to the rider. One pole of a local circuit, containing a sounder, is attached to the reed and the other pole to the rider. When the reed vibrates the rider trembles upon it and makes the connection in the local circuit so poor that the

sounder opens; the instant the reed stops vibrating, the adjusting screw pulls the rider firmly down upon it, restores the circuit and the sounder closes. So that when the sending key is open, it being so arranged that the vibrator is then to line, the receiving reed is in motion and the receiving sounder is open; close the sending key, the vibrator is thrown out, the receiving reed becomes quiet and the sounder closes, producing the same effect as in sending over a single wire with ordinary Morse apparatus."

By this method how many tones may be practically transmitted at once?—Theoretically as many tones may be transmitted simultaneously as there are different reeds employed. "Professor Gray has transmitted as many as eight tones at once, but the margin between them was so small and such very delicate adjustment was necessary that, for practical work, he adopted four tones only; therefore as operated at present, four vibrators with different fundamental tones are placed at the sending end, and four receivers, so tuned that each will equal one of the vibrators in tone at the receiving end of the wire, and the four series of vibrations are transmitted simultaneously, each receiver responding only to its own sender. Thus, we have four messages going in the same direction over one wire, and at the same time. In order to break, resistance is thrown in and out by the opening and closing of a key at the receiving end, which throws a relay that has been adjusted over the tone current at the opposite end out of adjustment and records the signals. All the receiving operators use the same break key without confusion."

Explain the operation of the sending apparatus.—A *transmitter* is used similar in form to that in the duplex apparatus but modified in some particulars.

"When the reed swings to the left the battery is short-circuited through the transmitter lever, lower spring and contact points. When to the right the metallic circuit is broken and + pole finds ground at the home, and – pole through the line at the

distant station. Instead of actually opening and closing the battery, the action of the vibrator only reduces its strength about 60 per cent., and, as it is necessary that the same amount of current should always be to line to allow of the break relays being adjusted over it, the points are so arranged that when the transmitter is closed, cutting off the vibrator, the upper spring and point come into contact and throw about 40 per cent. of steady current to line. So that, whether the key be open or closed the same battery strength is always going to line. When the key is open it is being sent in pulsations (too close together to affect a Morse relay), and when the key is closed it is being sent steadily."

Explain the operation of the receiving apparatus.—"When the reed in the receiving relay is in a state of vibration caused by the action of the incoming waves of currents, the local circuits in which is included the reed and rider, becomes so imperfect (caused by the riders trembling) that the sounder opens; when the reed returns to a state of rest the contact becomes perfect and the sounder closes.

The break key, when not in use, is left open, forcing the current to travel through about 3,000 ohms of resistance (or more according to the length of time) to find a ground. When the key is depressed, the current takes a new route of no resistance to ground, and the current is sufficiently increased, by having so much less resistance to encounter, that the magnet of the break relay, at the sending station, overcomes the tension of its armature spring and closes, recording the signals made upon the key at the receiving station."

What other systems of commercial telegraphy besides the Morse system and its improvements are in use at the present time?—In this country the American combination printing telegraph, comprising the Hughes combination and Phelps improvements. And the Phelps electro-motor printing telegraph, used chiefly on trunk lines between New York and the larger cities. And the

automatic system known as the American "Rapid Telegraph." In addition to these may be added the "Special systems" of the Gold and Stock printing telegraphs, the District telegraph service, the Fire and Police telegraph systems, the telephone, etc., etc.

In England the Wheatstone, Needle, Dial, and Automatic systems are much used. But in nearly every civilized country the Morse system is principally used, on account of its "simplicity," "speed," and comparative accuracy.

There is, however, almost an endless variety of contrivances for transmitting and receiving messages, involving different applications of electric and chemical science, for descriptions of which the student is referred to larger treatises.

SECTION XXXII.

SWITCHES OR CUT-OUTS, SWITCH-BOARDS, GROUND WIRES AND LIGHTNING ARRESTERS.

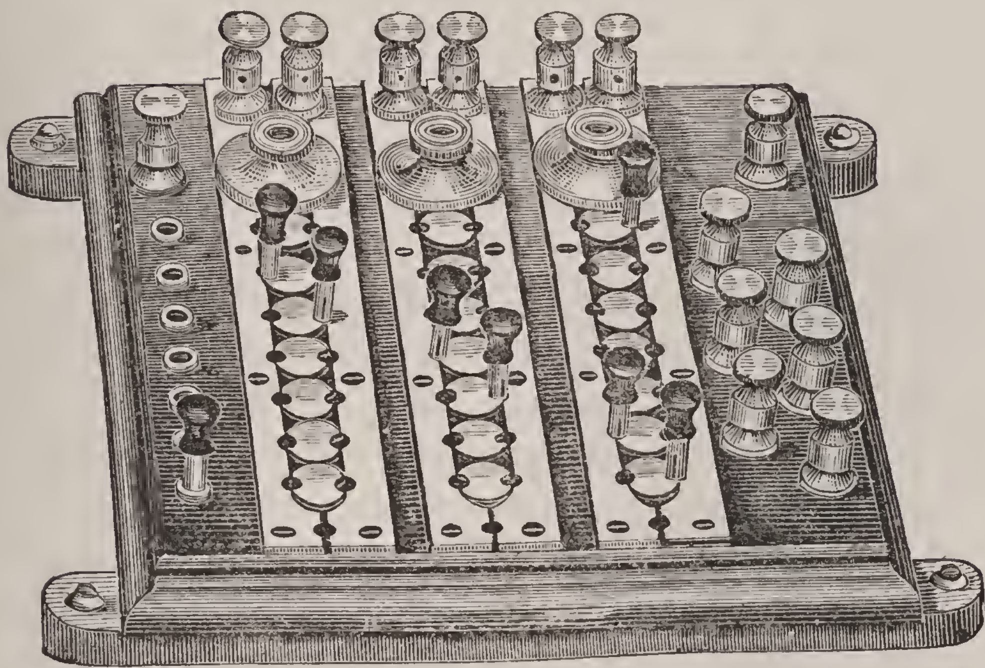


Fig. 14.—Western Union pin switch with improved disc lightning arresters.

In addition to the instruments already described, what other contrivances are usually employed in telegraph offices?—Switches, or cut-outs, switch-boards, ground wires, lightning arresters, and in principal offices some others.

What is the switch or cut-out?—A contrivance designed to connect or disconnect the instruments from the main circuit without interrupting it, and may be divided into two classes, one in which the instruments are cut out by being merely short circuited and making new circuit connections, thus changing the course of the current, and the other, in which the instruments may be cut out and entirely disconnected from the line, which is preferable, as it insures the safety of the instruments during thunder storms.

Describe each method?—The short circuiting method consists

simply of two or more brass plates with holes provided for the insertion of pegs with insulated handles, so arranged that when the plates are attached to the circuit the insertion of the peg forms an electrical connection from one to the other, thereby cutting out the instruments from the main circuit. This apparatus is usually made in combination with a lightning arrester and ground wire connection.

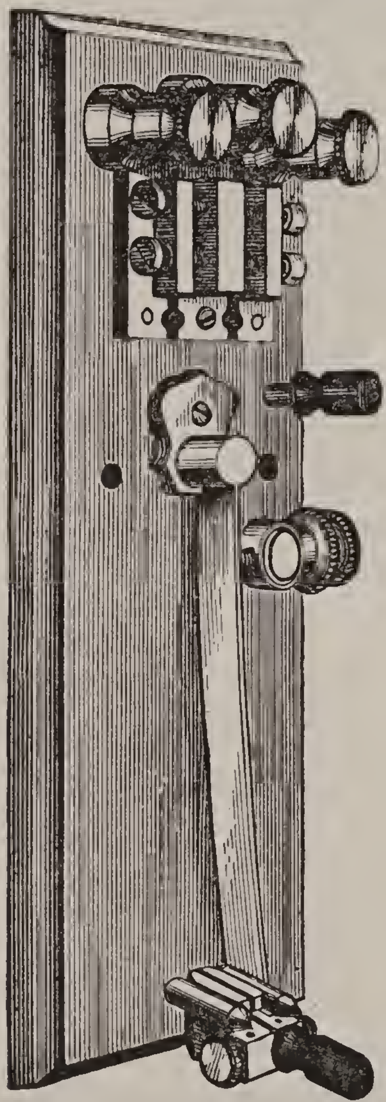


Fig. 15.

The other method called the plug or wedge cut-out (Figure 15), by which the instruments can be totally disconnected from the line, is probably the best and most universally used at way stations where there are only one or two wires. It consists of a wedge in combination with a spring-jack contrivance, invented in 1855 by G. F. Milliken, of Boston, Massachusetts. The plug or wedge to which the instrument wires are connected, consists of two pieces of brass insulated from each other by means of a thin plate of hard rubber provided with a handle of the same material, and the spring-jack consists of a base board with binding screws at the top for the line wires, and an elastic strip of brass rigidly attached at the upper end, and in connection with the right hand binding screw by means of a wire underneath, while the lower end of the strip is armed with a brass pin which presses firmly against a stationary pin in connection, by means of a wire underneath the base, to the other binding screw. The pressure of the brass strip against the stationary pin is regulated by a set

screw. When the wedge is inserted between the two pins, it separates them, breaking the circuit of the main line, but at the same instant opening a new path for the current through the two metalic sides of the wedge and the instruments; thus the latter may be inserted into or withdrawn from the main circuit without interrupting it. The arrangement may also be used for connecting batteries as well as instruments. This cut-out is frequently provided with a lightning arrester and ground connection arranged with pegs, as seen in the engraving.

What is the switch-board?—A combination of switches adapted to form various combinations of several different circuits. By its use every possible interchange of connection required can be made quickly and easily, testing operations carried on, instruments changed from one wire to another, loops connected or disconnected in any wire, and batteries connected, disconnected, or reversed, and is used almost universally in telegraph offices, where there is more than one wire. Where a number of lines enter the same office they are all brought into the same switch-board, and in cases where the necessities of the service require it, wires are led from it to a separate set of instruments for each line, but in way stations it is more frequently the case that a smaller number of instruments is sufficient, and the necessary changes provided for by means of the switch-board, whereby any one of the instruments can be inserted into the circuit of any required line at pleasure.

What form of switch-board is most generally used in this country?—Switches are made in a variety of forms according to the uses for which they are designed. Probably the one most generally and universally used in this country is the "peg" switch (Fig. 14), so called from the metallic plug or peg, used in forming or changing circuit connections. This switch has been adapted by the Western Union Telegraph Company as a standard, and is as near perfection with its spring-jack appliances as can be desired.

Describe its construction.—In its simplest form, devoid of spring-jacks and other auxiliaries which enter so largely into its composition in the large city offices, the peg switch is composed of a series of vertical metallic bars, or strips, to which are attached the line wires, and of a number of metallic buttons, or discs, placed horizontally, each separate row connected together at the back of the base board by means of a copper wire terminating in binding screws at the side. To these latter are connected the instrument wires. "Each disc has a semi-circular hole cut in its edge at each side, and each bar has the corresponding semi-circle cut opposite the hole in the disc, so that a metallic plug, put in any of the holes, presses against both the upright and cross bar, thus making the connection." The pegs should, however, always be crowded firmly into the holes, with a twisting motion, in order to insure a proper connection.

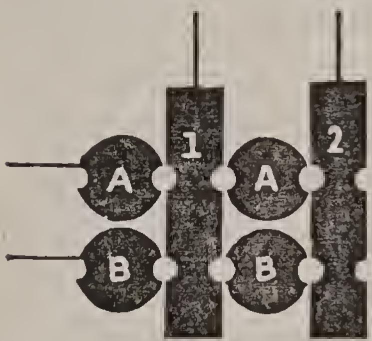


Fig. 16.

Explain the operation of the "peg" switch as adapted to the requirements of a way office?—"The accompanying diagram, Fig. 16, shows the connections of the peg switch as adapted to the requirements of a way office. It is so simple, and yet so perfect, that only a very brief explanation of the reference marks upon the cut will be necessary to a full understanding. 1 represents a vertical metallic bar, or strip, upon the switch, to which is connected a wire running into an office, and 2 represents the same wire going out. A and A′ and B and B′ are metallic buttons, to which are connected the instrument wires. All the buttons upon the same horizontal line, are connected together at the back of the switch.

As shown in the cut, the circuit is "open." To close it, with instrument in circuit, it would be necessary only to insert two metal plugs, or pegs; one at the orifice at B′ and 2, and one at A and 1. The course of the current would then be as follows: From the line at 1 through the peg connection at A to instru-

ment; through instrument to B and B′; through the peg connection there to the line at 2, and so out to the main line. Should it be desired to connect the line through, without instrument in circuit, the insertion of pegs in the orifices of either A′ or B′ would effect the desired result.

The same form of switch, with a modification of connections, would answer for a terminal office.

For this, let it be understood that a wire, leading from a battery, one pole of which is grounded, is taken directly to one side of the instrument; through the instrument it goes to A; from A, if a peg be inserted in its orifice, it goes to 1 and to the main line.

If, instead of placing the peg at A and 1, it be placed at A′ and 2, the instrument would be connected to line 2."

Describe the peg switch as adapted to the requirements of a large office.—Both the peg-switch and the wedge cut-out are employed, the latter changed in style and appearance somewhat, but still based on the original principle, and consists of wedges of hard rubber, having a thin brass strip upon each side, one being attached to one end of the instrument wire, and the other side to the return wire by means of a flexible conducting cord. In large offices the switch is divided into sections, each section accommodating a certain portion of the lines entering the office. The line wires are connected to the lower end of the vertical bars by first passing through the spring-jacks, and the batteries connected to the discs, between each pair of upright bars, the extreme left hand row of discs having a distinguishing number engraved upon it. However, one row of horizontal discs is connected directly with the earth. Immediately underneath the lower end of the vertical bars are placed a corresponding number of spring-jacks, and beneath these again still another series of spring-jacks. Each main wire coming in from outside passes first through one of the upper spring-jacks, then through the lower one corresponding to it, and thence to its appropriate

vertical bar; each spring-jack bears upon it the number of the circuit to which it is attached.

The lightning arrester is usually placed at the top in this class of switch board, in the shape of a brass bar connected to a ground wire, and placed horizontally across all the upright or line bars, as close as possible to them without touching, or in the shape of discs placed across each pair of upright bars (as seen in Figure 14). In the larger offices, however, the lightning arresters are not attached to the switch, but placed at the point where the lines first enter the building. In front of the switch is usually placed a shelf or counter containing the necessary instruments used by the chief operators for testing purposes, which can be thrown into the circuit of any required line at pleasure, as they are connected with wedges by means of flexible conducting cord.

What is the ground wire?—A wire so situated that it may at pleasure be made to connect the line with the earth.

For explanation of how the ground wire should be connected to the earth see section XXI.

How many ground wires are there on a line?—As many as offices; each office has one. However, for the different distinct services required of ground wires it would be better to use a separate wire connected to the earth at different points.

Are they always in connection with the circuit?—The terminal ground wires only are always connected. The others are never used, except when the line is out of order, or when it is desired to work a part of it only.

What is the effect of connecting the ground wire to the line?—It divides the line into two independent circuits, and forms a common conductor for both currents on the same principle that the earth forms one-half of every main circuit.

What is the lightning arrester?—It is a contrivance (usually in connection with the switch) designed to protect the telegraphic instruments from the effects of heavy charges of atmospheric electricity which sometimes traverse the line.

Upon what principle is it constructed?—Upon the principle that atmospheric electricity, possessing a high tension, prefers to overleap a slight break in order to reach the earth by a short conductor, rather than to traverse a long circuit.

Of what does it frequently consist?—Of two metallic plates whose surfaces are separated by mica. One of these plates connects with the ground wire, and the other with the main line.

Explain its operation.—The instrument being constructed in this or some similar manner, the resistance of thin mica is all that prevents communication between the line and the earth. This resistance the ordinary Voltaic current is unable to overcome, and hence is obliged to keep on in the main circuit. But on the other hand, a discharge of atmospheric electricity passing along the line and reaching the lightning arrester through the mica between its plates, enters the earth by the ground wire, thus being diverted from the relay.

Mention another form of this instrument.—As lightning passes with facility between points, another form, probably the most frequently employed, is a brass plate, containing saw-teeth or pointed screws arranged between, and in close proximity to other plates of brass, these plates provided with suitable binding posts for connecting the wires; the middle plate with the teeth or screw point is the lightning arrester proper, and should always be connected to the ground by a good heavy copper wire; the other plates connect with the line.

As none of these devices can be considered an absolute safe-guard, what precaution should be observed whenever atmospheric disturbances become serious?—The instruments should be cut out from the line in such a manner as to leave *no break* in the circuit; during severe thunder-storms this precaution should never be neglected.

SECTION XXXIII.

THE GALVANOMETER, WHEATSTONE'S BRIDGE, RESISTANCE COILS, RHEOSTAT, CONDENSER, VOLTAMETER, AND ELECTROMETER.

The galvanometer is one of the results of Oersted's discovery, and is applied to a great variety of uses in connection with electrical science, and in some form is almost an indispensable requisite in every class of electrical measurement. especially so in practical telegraphy.

What is the galvanometer?—It is an instrument designed to detect the presence of a current, and is used for testing, for measuring electrical resistances, for comparing electro-motive forces, and for measuring the intensity of the current, and locating faults on lines and cables.

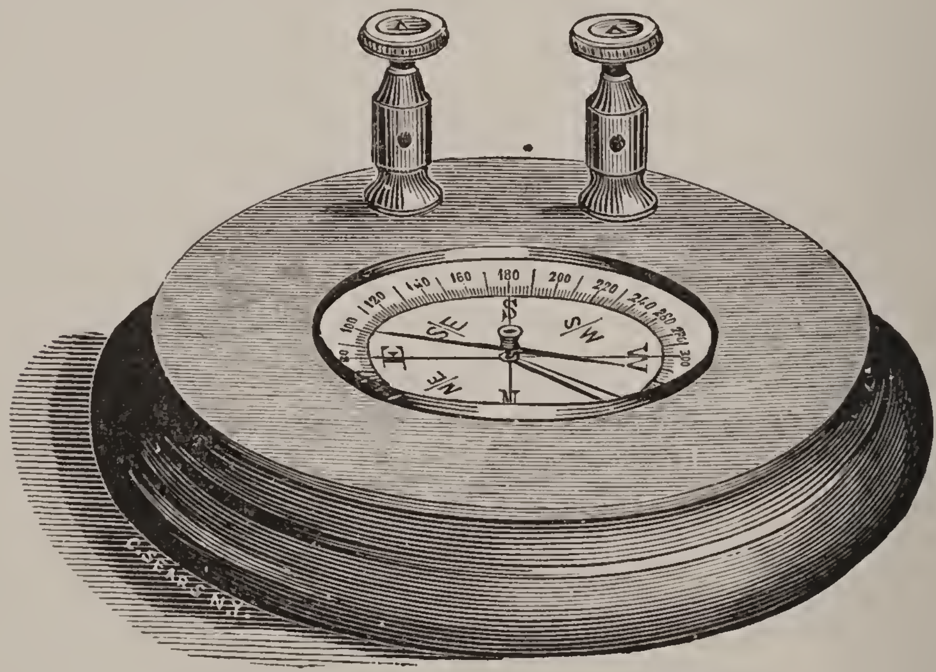


Fig. 17.—Detector galvanometer.

Explain the construction of the galvanometer.—It is made in *many forms*, and for various purposes. All forms of the instru-

ment consist of a coil of insulated wire and a magnetic needle freely suspended in such a manner as to be easily deflected by the passage of a current through the coils. A scale divided into degrees is usually added, by means of which the angle through which the needle is deflected from the magnetic meridian may be conveniently ascertained.

What is the simplest form?—The simplest form, known as the *galvanoscope*, or the detector galvanometer (see Fig. 17), consists of a simple magnetic needle freely suspended, popularly called a compass, surrounded by a coil of copper wire, the different convolutions insulated from each other. When brought near a voltaic current it tends to place itself at right angles to the direction of that current. In another form the needle is weighted at one end, and hung perpendicularly in the coil; when the current flows it tips to the right or left as the case may be.

For what purpose is it employed?—To show the presence of a current upon the line. For this purpose it is connected in the circuit, and when a current is passing, the needle is thrown aside from its natural northerly and southerly direction, and thus by its movement manifests the presence of the current, even when the relay fails to do so.

How does it show when the line is in operation?—By the violent agitation into which it is thrown by the repeated cessation and renewal of the current.

The influence of the current upon the needle is modified by the magnetism of the earth; the current must overcome this terrestial influence before it will cause any movement of the needle, consequently, but little if any deflection will be produced by a *very weak* current. A free magnetic needle always tends to place itself at right angles to the path of the current, and would actually assume that position if it were not for the magnetism of the earth, which prevents even the most powerful current to deflect a needle sufficiently to cause it to assume a position exactly at right angles to the path of the current.

What is the most sensitive form of galvanometer useful as a means of detecting the presence of an electric current?—The most sensitive galvanometers are those known as the *astatic* sys-

tem of needles, which consists of two separate needles, coupled together and placed in the same perpendicular planes, one directly over the other, but with their north and south poles opposite to each other. If the magnetism of the two needles were exactly equal, they would remain at rest in any position in which they were placed. But in practice one needle slightly overpowers the other, and by this excess determines the position of equilibrium. The coils or conducting wire is arranged in such a manner that it will tend to deflect both needles in the same direction. "A light pointer or index is placed upon the axis above the upper coil, which traverses a scale divided into degrees, and serves to indicate the angle of deflection of the needles."

What is meant by the term deflection?—The angle or number of degrees through which the needle of a galvanometer moves when a current is passing through its coils.

What are the principal galvanometers now in use?—The tangent and sine galvanometers, the differential, and Thomson's reflecting galvanometer, and the Wheatstone bridge system of measurement.

What is a tangent galvanometer?—A tangent galvanometer is an instrument so constructed that the mathematical tangents of the angles of its deflections are in all cases strictly proportional to the strength of the currents by which the deflections are produced.

How is this effect produced?—This effect is produced by so arranging the conducting wire relatively to the magnetized needle, that the current traversing the conductor will act uniformly upon the needle in whatever position it may place itself, or in the same manner that the earth's magnetism does, and consists essentially of a ring having a groove on its edge filled with wire. The needle is hung or pivoted precisely in the centre of the ring, and must not be longer than one-sixth of its diameter, an inch-needle requiring at least a six-inch ring. The

arrangement is as if a short compass-needle enclosed in its box were placed in the centre of the ring.

What is meant by the term tangent?—A *tangent* is a line drawn at right angles to one of the radii of a circle, and touching its circumference.

For what purpose is the tangent galvanometer employed?—Although this instrument is not so sensitive as other galvanometers, on account of the distance between the coil and the needle, it is regarded as the *most convenient* form for general purposes, and extremely useful for testing lines, because of the length of its scale and its accuracy.

What form of this instrument is extensively used in the United States?—A form of construction invented in 1866 by Dr. L. Bradley, of Jersey City, combining in a high degree the merits of compactness, portability and accuracy, and is probably the most accurate tangent instrument made.

Describe its construction?—It consists of a circular or disc needle, either composed of a single piece of steel, or of several short needles placed side by side, and the whole trimmed to form a circle. The north and south poles of the circular needle are at opposite points upon its circumference. Light aluminum pointers are attached to this disc for registering its movements. The needle is balanced upon a steel point, on which rests an agate. The coil is flat and is placed directly underneath the needle and in close proximity to it, so that the current runs parallel with the meridian of the needle. The breadth of the coil slightly exceeds the diameter of the needle. In this instrument four coils are used, the first 150 or more ohms, the second 25 or 30 ohms, the third, one to two ohms, and the fourth is a strip of sheet copper of the width of the coils, and wound three and a half times around the needle. The first coil is used for high resistance, the second and third for medium resistances and the fourth for very low resistances, or those of great quantity. The outer ends of all the coils are connected with a common

binding screw; while the inner ones are each connected with a binding screw bearing its proper number.

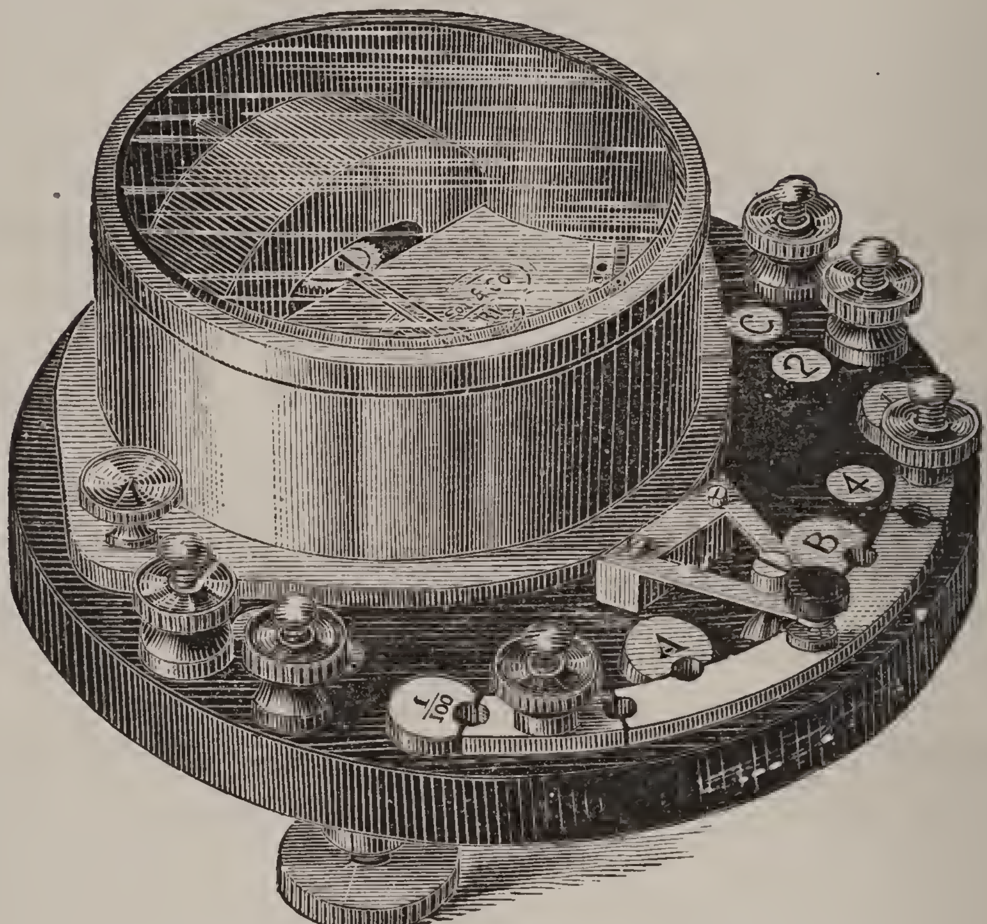


Fig. 18.—Standard differential galvanometer.

What is a differential galvanometer?—The differential galvanometer is one whose needle is acted upon by two coils of equal length, resistance and power, and shows the difference in strength of two currents. It is wound with two wires, side by side, so arranged as to be exactly equal in ther effect on the needle. This instrument is used to measure resistances by comparing them with the standard resistance coils. Fig. 18 gives a good illustration of the standard differential galvanometer.

What is a sine galvanometer?—A *sine* galvanometer is one which may be *astatic* or not. The needle is pivoted or suspended horizontally, and the coils are made so as to be capable of turning on the axis round which the needle turns; the coils

are turned by hand so as to follow the needle as it is deflected by the current. The strength of the current, in a *sine* galvanometer, is proportional to the *sine* of the angle of deflection. This instrument is chiefly used for measuring and comparing weak currents.

What is meant by the term "sine"?—The sine of any number of degrees is that part of the diameter of a circle which is included between a line drawn from its center to the zero point of the graduation circle, and another line parallel to the first, cutting the circle at the degree whose sine is required.—*Culley.*

How may the sensibility of a galvanometer be varied?—By the use of what is termed a *shunt.*

What is a shunt?—A shunt is a resistance coil, or coil of fine wire used to divert some definite portion of a current, leading it past a galvanometer instead of through its coils, which, as a whole, is too powerful to pass through the instrument coils. Most galvanometers are usually provided with three shunts. A fine wire galvanometer may be *shunted* so as to be used for testing very small resistances.

Explain Thomson's reflecting galvanometer.—This beautiful apparatus, invented by Sir William Thomson, of Glasgow university, is the most sensitive, and probably the most generally useful instrument of the kind ever devised. It is generally made *astatic*, and consists of a mirror of microscopic glass about one-eighth of an inch in diameter, suspended by a silk thread in the center of a coil of very fine wire. Four very small magnets, one-fourth of an inch long, are attached to the back of the mirror, one above the other. A scale of equal parts is placed two or three feet from the mirror; with a narrow slit cut in the center to allow a ray of light to shine upon the mirror from a lamp placed behind it. This ray is reflected back upon the scale and is the index of the galvanometer; the angle through which the ray moves is double that traversed by the mirror, and it is therefore really equivalent to an index four or six feet in length, with-

out weight. When the scale is three feet from the mirror, each degree of deflection moves the spot of light more than an inch, the great length of the index thus renders the slightest movement of the mirror perceptible. The magnet is so sensitive that if the ends of the wire connecting the coil are held by the hands, one end being covered with tin-foil, there will be sufficient magnetism excited to deflect the needle. If a current equal in strength to that produced by a knife blade, when brought near a magnetic needle, is received, it will move the magnet. An adjustable permanent magnet is usually placed in the magnetic meridian, above the coil; by raising or lowering this magnet the action of the directive force of the earth upon the suspended magnet may be increased or weakened at pleasure.

For what purpose is this galvanometer used?—For very delicate measurements and high resistances, and is employed as a *receiving instrument* in connection with submarine cables.

What is the principle of the Wheatstone balance or bridge?—It is usually represented by a diamond shaped parallelogram with two of the opposite corners connected by a cross wire having a galvanometer in circuit, and the other two opposite corners connected respectively to the two opposite poles of a battery. Any good galvanometer may be used with it. Three sets of resistance coils are arranged so as to form the three sides of the parallelogram, the wire to be tested forming the fourth side. In practice, however, the apparatus does not bear the form as usually represented in diagram, but is arranged so that the coils may occupy as small a space as possible. Strictly speaking the Wheatstone balance or bridge is a system of measurement instead of a galvanometer. Two keys are used in connection with the apparatus for making and breaking contact; one inserted in the battery circuit, and the other in the bridge or cross wire.

For what purpose is the Wheatstone bridge employed?—For measuring resistances by balancing the unknown resistance against one known and capable of adjustment.

Mention a form of galvanometer constructed on the Wheatstone bridge principle.—Siemens' universal galvanometer much used in various parts of the country. It consists of a comparatively sensitive galvanometer the needle made astatic, combined with a Wheatstone bridge, and three resistance coils contained in a sort of casket, and when kept free from outside influences, to which it is very susceptible, and connected in a circuit it points out, with unerring distinctness, the exact condition of the electric current, or when anything is wrong with the wires.

What is meant by taking the "constant" of a galvanometer?—To ascertain the deflection of the galvanometer needle, through a standard resistance coil by means of the battery used for testing.

What precautions are necessary in using any galvanometer?—Great care should be taken not to allow too powerful currents to pass around the needle, as such currents are liable either to change the magnetic intensity of the needle or to reverse its polarity altogether, hence, in order to avoid injurious effects, the currents should not be allowed to act upon a galvanometer for a longer time than is necessary; during thunder-storms this instrument should never be used.

As delicate galvanometers are disturbed by pieces of iron or steel in their immediate neighborhood, when the instrument is being used all such things should be removed from its influence; however, if enclosed in a sheet-iron case or placed on an iron plate, the disturbing effect of outside influences is cut off, as magnetic power is acquired by induction. The force acts through all substances not themselves capable of being magnetized. A compass in a brass or wood box is as easily affected as if it were not so enclosed; but if shut in an iron box, a magnet outside would act on it indirectly only, and feebly, through the magnetism induced in the iron of which the box is composed.—*Culley.*

What is a resistance coil?—An ordinary resistance coil is of unchangeable length, usually consisting of German silver wire insulated by a double covering of silk, and wound on ebonite bobbins or spools, one half in one direction, and the other half in the opposite direction, which prevents induction; when wound the bobbins are saturated with hot paraffine, which preserves the insulation, and prevents the silk covering from becoming damp.

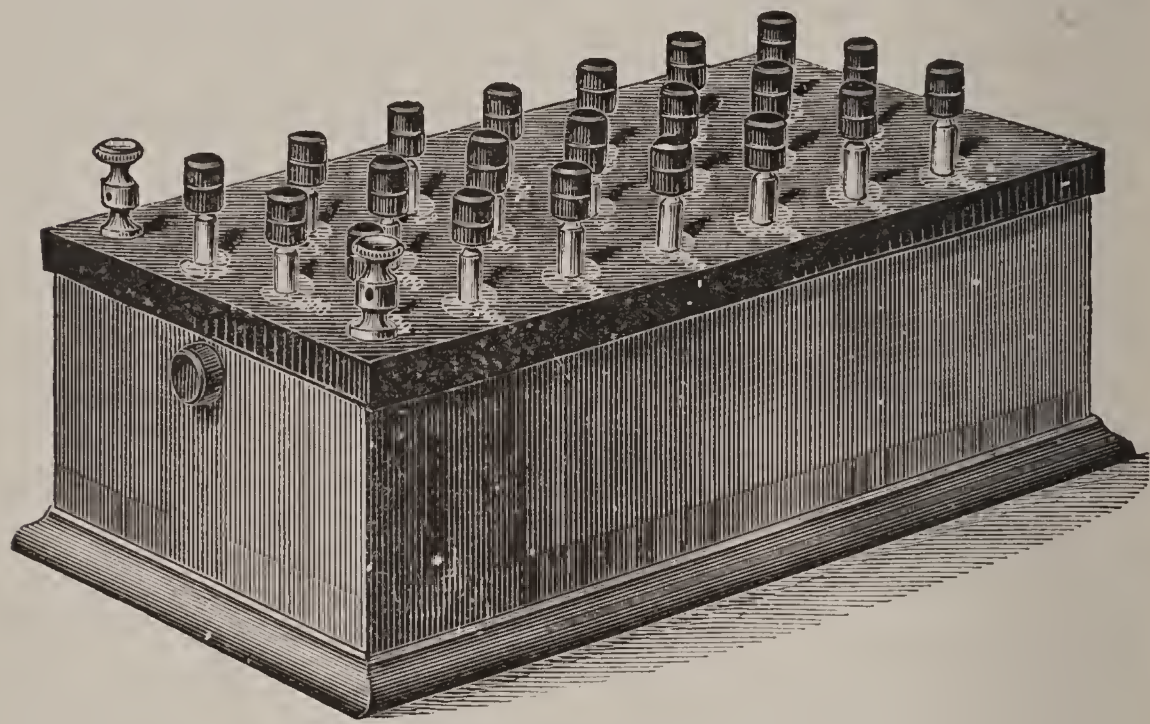


Fig. 19.—THE RHEOSTAT.

What is the rheostat?—A set of resistance coils so arranged that the amount of resistance in any given circuit may be measured or regulated at pleasure.

Does the construction and arrangement of the rheostat vary?—Yes, depending in a great measure upon the conditions, under which it is intended to be used, whether for the insertion of large or small resistances into the circuit. They are used to construct an artificial line, which may be contained in a small space, and yet produce the same effect upon a current as an actual line of great length.

Explain the princible of the standard rheostat?—It consists of

a combination of several resistance coils, ranging from one ohm to ten thousand, securely enclosed in a mahogany or rosewood box. To economize space, the small resistances are made of thick wire, the higher ones of thin wire; a series of short metallic blocks are placed at equal distances apart and screwed down to a plate of ebonite, which forms the top of the box in such a manner, that they can be connected together by means of brass pegs inserted between them at pleasure. The brass blocks connect with the ends of the coils beneath, and the line and battery wires are connected to these by means of binding screws placed in the top of the box. (See Fig. 19).

What is meant by such expressions as a fifty mile, one hundred, or two hundred mile rheostat?—Such expressions refer to rheostats that introduce into the circuit a resistance equal to that of fifty, one hundred or two hundred miles respectively, of ordinary line wire.

What is a condenser?—It is an apparatus by means of which a large quantity of electricity can be gathered on a small surface.

How is it constructed?—Its form may be greatly varied, but the essential parts consist of two good conductors, which are separated from each other at a small distance by a non-conductor, and is usually made of alternate sheets of tin foil and various insulating substances, such as sheets of thin glass, mica, gutta percha or paraffine paper, the leaves laid singly one upon another like the pages of a book, and the tin foil sheets connected together in two series upper and under, each by themselves.

What is the use of the condenser?—It is used in connection with the duplex, quadruplex, and automatic telegraphy, submarine cables, induction, apparatus, and for comparing the electro-motive force of batteries.

What is the voltameter?—An apparatus for measuring the current by its chemical action.

What is the electrometer?—An instrument for measuring difference of electric potential.

SECTION XXXIV.

TELEGRAPHIC FAULTS OR INTERRUPTIONS.

Aerial telegraph lines are constantly exposed to interruptions and variations in resistance. "Every shower of rain, fog, dew, and mist affect its resistance. Lines exposed to the spray of the sea, or to the smoke of manufactories are peculiarly liable to variations."

There are other causes besides the above which interfere with, and affect the working of, an aerial line. In the words of Mr. W. H. Preese, we enumerate many of the causes which relate to the irregularities to which an aerial line is peculiarly liable.

"It may be brought into contact with other wires upon the same poles by the position of the pole itself, being disturbed by falling branches, trees, or rocks, by high loads at crossings, by whiplashes, by kite strings and cotton waste, by careless workmen, and even by the wind itself when very high. Loose or broken stays may place the wire in contact with signal posts, walls, bridges, and trees. Trees, unless carefully lopped, may grow up amongst the wires. Joints may become bad from the absence or failure of the solder. Malicious or thoughtless persons may twist them together. Various moving accidents by flood and field disturb the wires, and these disturbances are evidenced by varied resistance. But subterranean and submarine wires are free from all these vicissitudes. The resistance of their insulating coating is practically constant. Cables lie beneath the sea upon a cushion of equable temperature, and they are far removed from atmospheric disturbances."

What is a telegraphic fault?—Any obstruction or impediment which interferes with the *constancy* of the resistance of the line affecting the currents, is a fault.

What are the principal faults to which the telegraph is liable?—Breaks, partial disconnections, defective insulation, causing escapes or partial earth, dead earth or "a ground" crosses, swinging crosses, weather crosses, and defective earth connection at the terminals.

What other causes interfere more or less with the working of the circuits?—Earth currents, depending on the variation of the difference of potential at the extremities of the line, or on induction from the free electricity in the air and in the clouds.

Does the electrical condition of the atmosphere produce any effect upon the telegraph?—It does, often causing heavy charges of electricity to pass along the line, such discharges being the most frequent during or immediately before thunder storms, often injuring the instruments. All great terrestrial and atmospheric changes are accompanied by *electrical disturbances* which produce their effect upon the line, especially those which culminate in aurora, electric storms, thunder storms, and earthquakes. Electric storms are generally preceded or accompanied by aurora, and produce currents of great strength, often overcoming entirely the working current.

These currents are sometimes steady, but they more generally vary rapidly in strength and duration. Thunder storms are also accompanied with current effects, which disturb the working of the wires, and there are many authentic cases of such currents preceding earthquakes. In fact, telegraph wires are subject to a constant state of variation and change.

What is a break?—Any accidental rupture of the line, causing total disconnection.

How may breaks be classified?—Into three kinds.

1st. Neither of the ruptured ends communicate with the earth.

2d. One end communicates with the earth.

3d. Both ends communicate with the earth.

What follows a break of the first kind?—A total suspension of current throughout the entire line.

What of the second?—Suspension of current on that end of the line which does not communicate with the earth. The other end forms a short circuit.

What of the third?—Each end of the line forms a short circuit.

How is a break manifested?—By the refusal of the line to work its entire length.

What is a swinging break?—A break or disconnection which makes itself manifest by opening and closing the circuit at long and short intervals, caused either by the effect of the wind on a loose joint in the line wire, or from a loose connection in the office, or sometimes done *by means of the key* for the sake of annoyance.

What is a partial disconnection?—Partial disconnection occurs when the resistance of the line is greatly increased, and may be caused by a rusty or bad joint in the wire, dirt at the contact points of the apparatus, or imperfect connections, or by an imperfect terminal ground connection, or it may be caused in the main battery, when not in proper condition.

What is the effect of a partial disconnection?—A fault of this kind so weakens the current, that the instruments in circuit work very weak.

What is an escape?—Such a connection of the line with the earth that a part or all of the current escapes. The amount of escape depends essentially upon the insulation of the line, the character of the country through which it passes, and the nature of the weather.

In wet weather most lines are subject to some slight escape, which is usually equally distributed over the whole line, and some lines are much affected by defective insulation and interference of trees. "Short lines, as a rule, are little disturbed by

variations of short duration, but long lines, of 200 miles and upwards, are the subject of constant variations, due to atmospheric changes at different points. A thunder storm here, a shower there, excessive radiation at one point, cloudiness at another point—all tell their tale."

How many kinds of escapes are there?—Two; partial, when a part of the current escapes into the earth, and total, when it all does.

What is the effect of a total escape?—As in the case of a break of the third kind, each part of the line forms a short circuit.

What of a partial escape?—Offices on the same side of an escape can work with each other as usual, but a key in any part of the circuit cannot fully control the current beyond the escape; hence, messages are transmitted over the escape with greater or less difficulty, according to its magnitude. In this case it is necessary to adjust the relay spring higher for distant offices, and lower for those nearer.

Mention another form of escape which sometimes happens.—It sometimes happens that the operating table is covered with oil-cloth, so that a portion of the main current finds a passage through the oil-cloth while the key is open. This does not conduct any of the current to the earth, and cannot properly be called an escape, though every relay in circuit with a key on oil-cloth or enameled cloth must have a high adjustment to receive the writing from such a key. This trouble, however, does not in the least interfere with such office in receiving from other stations, nor does it at all affect other offices in working with one another. Oil-cloth covering for a table should be avoided, or a place cut out for the key, so that it may rest on the table.

What is a cross?—Any accidental communication between two or more lines allowing their currents to intermingle.

Between what lines does it generally occur?—Between lines running together along the same set of poles.

What is the effect of a cross?—The lines connected by it refuse to work independently; or, in other words, the current on each line is not properly controlled by the key, being more or less influenced by the current on the line or lines connected with it by the cross.

How may business be conducted on one of the lines so connected?—By opening all the others. The line not opened will then operate as if there were no cross.

Is it necessary that different parts of the same line should be used on opposite sides of the cross?—It is not, provided the intercommunication of the lines be perfect or nearly so; for in that case, even if parts of different lines be employed, the cross will in effect unite them into one.

What is a weather cross?—A leakage of the current in wet weather from one wire to another upon the same poles, caused by defective insulation.

How may it be prevented?—This fault may be prevented by "*earth wiring*" that is, providing a *good earth* wire so fixed on every pole as to allow the leakage at once to pass to earth without interfering with any other wire. This means of preventing the fault, however, is liable to produce considerable variation in the resistance of the lines.

What is a swinging contact?—One wire swinging against another, or against a tree or other conductor, but remaining in contact only a short time.

What is a local cross?—Such a connection between the relay magnet cores and the local circuit as sometimes produces an escape or partial ground, if the local battery is not thoroughly insulated.

Any operator can readily test his relay for local cross by touching ground wire to the soft iron cores. If it interrupts the working, it shows that the magnet wire is in connection with the iron cores, and if the armature strikes or touches the cores, or

the local circuit has any connection with the cores, a local cross is produced.

What is the effect produced by defective earth terminals?—When the terminal ground wire-plate or conductor is defective, and offers a sensible resistance, a current on any one wire connected to it divides itself among the remaining wires; making them appear to be all crossed, as it is customary to connect all the circuits of a station to one and the same ground connection.

What are earth currents?—"The potential of the earth varies at different times and in different places, from some unknown cosmical cause. By this variation of the difference of potential at the extremities of a line, currents are produced in the wires called *earth currents*, which vary both in direction and strength, sometimes rapidly, sometimes slowly. Lines running easterly and westerly are much affected by them, but not so much those running north and south. They are always more or less present, and vary diurnally with much regularity, apparently following the motion of the earth about its axis. These daily currents do not much disturb the working of the circuits, though they tend to diminish the speed of working of those long circuits which are exposed to their influence. It is, however, their occasional and exceptional variation which disturbs the working of circuits." Especially interfering with the telegraph when they reach their maximum, termed *electric storms*.

What is the effect of electric storms on the line?—Such atmospheric disturbances cause waves of electricity to traverse the line in rapid succession, interfering with the regular battery currents, sometimes admitting of the wires being worked by its currents, dispensing altogether with battery power; but such currents are variable in their force, and fluctuating in their action, and cannot be depended upon.

How may the lines be successfully worked during the prevalence of electric storms?—By forming complete metallic circuits of any

two wires between any two points, by disconnecting the ground wires at the terminal offices, and looping or connecting the lines together, with an independent battery in circuit. The effect of earth currents may be obviated in the same way where two wires affected run parallel to each other.

What is the effect produced upon lines by the aurora borealis or northern light?—It is sometimes similar to that of electric storms, but much less violent.

What general principle may be observed in regard to any telegraphic interruption which diverts from the line either all or a part of the current?—That between either main battery and the place of such interruption, the line will work perfectly with the use of the ground wire, and often without it.

There is frequently an exception to this rule in case of interruptions, which take place near the terminus of the line. In such cases, the distance between the place of the interruption and the remote terminus is often too great to be worked with advantage by a single battery.

What are reversed batteries?—Two batteries placed in the same circuit with like poles toward each other. In this case, if the line is perfect or nearly so, no current will pass over it though the circuit be complete—for each battery will oppose the other. In such a case a way office can get battery from either direction by putting on the ground wire, thus dividing the line into two independent circuits, neither interfering with the other.

SECTION XXXV.

ORDINARY TESTING—ELECTRICAL MEASUREMENT.

What is testing?—Testing, so called, is proving the electrical condition of the wires and instruments, and is usually done each morning before the day's work commences. This not only enables the chief operator to know their exact condition at the time, and remove any fault before it has increased sufficiently to

interfere with business, but the careful examination and comparison of the state of a circuit for an extended period provides *data* necessary for determining the distance of any interruption,

With a main battery at both ends of the line, how is no current on the line indicated?—By the relay magnet failing to attract its armature caused either by the line wire being broken, "reversed batteries," or a ground cuts off the main battery or the leading in wires are crossed, or an office key is open.

When "no current" is observed, what should be done?—Immediately try the ground wire to ascertain in which direction it is open, and when practicable report at once to the terminal office the result, from which instructions will be sent in regard to the proper method of procedure, in order to allow the uninjured portion of the line to be operated until the fault is removed.

What does it indicate should the application of the ground wire give no current either way?—That the line is either broken on both sides or else is open in the office.

What should be done to locate the trouble?—First *make sure* that the *fault is not in your own office.* In such cases always suspect the trouble in the office, and immediately proceed as follows: First open the key, then moisten the forefinger of each hand, and place them on the line wires, where they enter the switch. If a current is felt the trouble is in the office, and will usually be found in a loose screw-post—either in switch or relay—in screws that fasten wires to the legs of the key under the table, in loose or dirty circuit breaker of key, in the fine wire under the base of the relay used to connect the screw-posts with the coils of the itstrument, in an imperfect connection made by loose button or plug in switch, or in flexible wire used to connect instruments to switch, or in the office wires, that connect the instruments together.

What is the ordinary method pursued in locating crosses?—

A way office having two or more wires passing through it, will be frequently called upon by the terminal offices to open a wire, and say when open. This service should be performed promptly, and the line must *not be reported open*, *until it really is*, and when closed, it must be reported closed in the same manner.

The testing operator generally requests the most distant office to open one wire, and make dots upon the other, he then opens the second wire in his own office, and if the dots sent on the second wire are received upon the first, the trouble is between the two offices. While the other operator is making dots, the testing operator opens the key upon the same wire, but still keeps working the key, although the circuit is open—he then requests the distant office to open the first wire, and opens it also at his own office, this then leaves the second wire free from interference, and offices can be raised without difficulty, commencing from the most distant office, or an office about midway along the line, he then calls them in regular order, instructing each to send dots on the second wire, while his keys are closed. When the dots are received on both wires, the cross is between his office and the office sending, but if upon the second wire *only* the cross is beyond the station sending.

How can a way office locate a cross?—A way office can locate a cross by having other offices on the wire open it in turn while he writes on the other. The cross is located between the two contiguous offices, one of whom, by opening the wire, causes the writing sent on the other to disappear; and the other of whom, opening the wire, has no effect on the writing passing through the cross. The cross is, in the first place, decided to be east or west of the office testing by noticing from which side the writing from other offices seems to be most interrupted by the trouble.

What is the method in case of slight crosses or swinging crosses? The test is often made by the operator, placing the finger of one hand upon the ground wire, and the finger of the other hand upon the proper line wire in the switch board.

What causes may produce a cross in an office?—Line wires touching each other, a piece of metal, a damp wall, board or any conducting substance.

Which wire is maintained in case of a cross?—The wire running into the largest number of offices, and which can be made the most available.

In case of a cross, how can the wire or wires, which are to be opened, be made use of?—The nearest office on one side of the cross should take out the main line wire from the switch next the cross, and substitute a ground wire, and the first office on the other side do the same; this leaves the line free for the use of the respective offices on each side of the cross; when the cross is removed, the wires must be replaced.

What is the ordinary method pursued in locating escapes?—If the escape is so heavy that it can be worked over with difficulty, or not at all, it must be tested for in the following manner: The current will traverse the fault, and go to the earth through the leak, and thence back to the battery, even if the keys beyond the escape be open. An escape is readily located by requesting offices to open their keys in turn, and adjusting down, to see if there is any current on the line while the key is open. The escape is always between two contiguous offices, one of whom, opening his key, the escape disappears, and the other of whom, opening, leaves the current weakened, but not open.

What causes may produce an escape in an office?—Wires, switch or instruments, touching moist or metallic lead substance connecting with the earth. Examine office connections carefully if the trouble is near the office.

In wet weather a line with a main battery at both ends, troubled with a bad escape, may be worked better for through business by switching off the battery at the receiving end of the line.

When requested to do so, what is the best method to open the line?—This is best done in the switch formed of two flat brass springs and a plug between them, by inserting a wad of paper

penholder, or other dry, non-metallic substance between the springs; in some switches, removal of a peg or turning a button answers the same purpose. In case there is any doubt about the way the switch works, remove the line wire from the screw post at the top of the switch altogether. If there is but one wire, leave the key open half a minute, and then close it.

What is the best plan to ground one end of a wire in an office and leave the other end open?—This is best done by removing one end of the line wire from the screw-post at the top of the switch, and inserting the ground wire in its place.

What is meant by "cross-connect No. 1 and No. 2"?—This means to connect No. 1 south to No. 2 north, and No. 2 south to No. 1 north, or so that the wires will work through. The simplest way to do this is to take No. 1 north and put it in screw-post where No. 2 north is, then put No. 2 north in screw-post where No. 1 north was.

What is meant by "straighten Nos. 1 and 2"?—This means to restore the wires to their usual condition, and may mean, take ground off, close circuit, or anything that may countermand any change that has been ordered.

What is the duty of operators in case of interruption of the line?—Operators are expected at all times to observe the working condition of the lines, and when they receive information, or, from their own knowledge, know the wires to be broken, or on the ground between their own and the next office, they must at once send word to the chief operator, notifying him of such break, and take immediate measures to send out track men, or the telegraph repairer, to fix the line. Should the trouble be in or near an office, the *operator* must then give his *personal attention* to fixing up the line, or send some other competent employe to do so.

ELECTRICAL MEASUREMENT.

At principal offices, what method is pursued in locating faults?

—The tests are made by actual measurement by means of the tangent galvanometer and rheostat, especially adapted to the purpose, and is so delicate and exact, that any fault in the line a hundred miles away, can be located within half a mile of it, and at ordinary distances within a few hundred feet; for instance, if a defect occurs on a wire anywhere within the city of New York, the electrician in the central office can ascertain its location within half a block.

Are daily tests made of all important circuits?—It is usual to make two kinds of tests daily of each wire—1st, when the line is *grounded* at the distant end; and, 2nd, when it is *insulated.* The first is called conductivity resistance, and the second insulation resistance.

Are the results of these daily tests and of all interruptions in the working of the lines recorded?—Yes, in a book provided for the purpose; besides, all principal offices of the Western Union Telegraph company are required to fill out printed schedules, containing particulars of all tests, interruptions, etc., and forward to the electrician's office.

For electrical measurement what instrument is used in connection with the rheostat?—The galvanometer often made in combination with the rheostat as one instrument, with a switch attached, by means of which it may be moved from the standard resistance to the resistance to be measured.

What are the difficulties which present themselves in locating the distance of faults?—The varying resistance of the fault itself, and an absence of a correct determination of the true resistance of the several portions of the circuit, including, as many circuits do, apparatus and portions of wire of a different gauge and different conductivity.

With what method of apparatus may the most accurate measurements be obtained?—The most accurate methods of testing are by means of the differential galvanometer, or the

Wheatstone balance or bridge, and a set of resistance coils; however, accuracy sufficient for ordinary purposes may be attained by the use of a *tangent* galvanometer, with a delicately balanced needle and scale properly divided, and a standard resistance coil or coils.

How is the rheostat employed in measuring resistances in the circuit?—To measure resistance by any ordinary galvanometer, using resistance coils, we must first connect up the galvanometer in circuit with resistance to be measured and a battery sufficient to produce a good deflection. Note the deflection produced, then substitute the rheostat for the unknown resistance. When all the holes are plugged, the resistance is practically nothing. When any hole is unplugged, the current cannot leap the distance between them, and is obliged to pass from the first block through the coil below it to reach the second block. The resistance thus inserted is indicated by a number marked opposite the hole. In measuring a resistance peg after peg is pulled out until the needle is found to rest at zero. The resistances of the various coils that have been brought into the circuit by pulling out pegs, are then added together, which show the total resistance of the line, which has been balanced against them.

How does the apparatus show the course of the current?—By the direction of the deflection of the needle.

How does it show the force of the current?—By the degree of its deflection.

How does it show how many miles of line wire the current has to traverse to reach a fault?—By the proportion in which it divides when passed through the resistance coils, or rather by the amount of resistance of the coils added together.

How may the distance of an earth or ground be located?—The method given by Culley is as follows: The loop test is the most accurate, and should always be adopted whenever a second wire is available, because it is not affected by a variation in the

resistance of the fault. Shorten the length to be tested as much as possible and let all the instruments in circuit be taken out. Choose a good wire, one free from fault and similar, if possible, to the wire to be tested. Insulate both from earth at the nearest available point beyond the fault and let them be connected together there in a loop insulated from earth. Two tests must be made, the first to find the resistance of the entire loop, the second to find the difference in resistance of the portions on either side of the fault or how much must be added to the shorter portion to make its resistance equal to that of the longer. If the rheostat is not sufficient to measure the resistance, that coil of the differential to which it is attached may be shunted, in which case the reading must be multiplied by the value of the shunt.

How may the line resistance be measured from an intermediate station?—The method given by Mr. F. L. Pope with the Bradley or any good tangent galvanometer is as follows: Connect the main circuit so that it will pass through 1 and 11 of the rheostat, and through the No. 1 coil of the galvanometer. When the circuit is closed for a few seconds take a reading of the deflection, then unplug a sufficient resistance to reduce the deflection perhaps one-half (1,000 or 2,000 ohms will usually answer,) and take a second reading. It is well to reverse the connections and repeat the two observations and take the mean result of the two deflections.

How may the internal resistance of a battery be measured?—There are various methods of determining the internal resistance of a battery. The method given in "Haskins' Galvanometer" is as follows: Put the battery in circuit with a sine or tangent galvanometer. Note the deflection. Halve the tangent of the deflection by introducing resistance. The resistance introduced is equal to the original resistance—that of the battery and the galvanometer coil. Deduct the latter and you have the desired result.

Are way offices allowed to put instruments in circuits they do not usually work?—Way offices should never put instruments on wires they do not usually work, without instruction from the chief operator in charge of the circuit, except in cases of interruption of their regular wires, when they can use any wire that may be working to ask instructions. Putting in relays without orders may destroy the results of tests being made, and if the wire be in use for duplex, quadruplex, or automatic instruments, the addition of another relay may, by its added resistance and induction, seriously disturb the working of the circuit.

Orders by proper authority to make changes in wires should be at once obeyed. In case anything occurs which prevents the carrying out of the order, the person who gave it should be notified at once.

SECTION XXXVI.

SUBMARINE TELEGRAPHY—THE ATLANTIC CABLES.

When was the first submarine cable laid?—The first submarine cable was laid August 27, 1850, from Dover, England, to Calais, France, across the channel, and communication was made telegraphically through the wire. This was soon interrupted however. But in 1851 another and better cable was manufactured and successfully laid. The first Atlantic cable was laid in 1858, but completely failed after working only twenty-six days. Various reasons are given for its failure, but it is generally conceded that the insulation was destroyed by a too-powerful current. The first Atlantic cable to work successfully for any length of time was laid in 1866.

Describe the general construction of submarine cables.—Long submarine cables consist of a strand of several copper wires acting as the conductor.

" Each of the Atlantic cables, old and new, is a one-wire con-

ductor, seven copper wires (six wound around one) acting as a single conductor."

The conducting wires are *insulated* by several layers of gutta percha, or a compound called Hooper's india-rubber, and a serving of jute. And for protection the whole is surrounded by an armor consisting of several strands of large iron wire each enveloped in fine strands of manilla hemp, the diameter of the cable being about an inch.

What is the average age of an Atlantic cable?—Experience has shown that the life of a cable is from ten to twelve years. If a cable breaks in deep water after it is ten years of age, it cannot be lifted for repairs, as it will break of its own weight; and cable companies are compelled to put aside a large reserve fund in order that they may be prepared to replace their cables every ten years. The action of the sea water eats the iron wire completely away, and it crumbles to dust, while the core of the cable may be perfect. The breakages of cables are very costly, and it is a very difficult matter to repair them, in comparison with a land line. Cables can only be repaired in the calmest seasons, and a ship chartered at great expense is often two or three weeks in fixing the locality, and in avoiding rough weather.

Explain in brief the difficulties to be met with in submarine telegraphy.—The peculiar conditions, which are met with, require the use of batteries of very small power in order to avoid any possibility of injury to the insulating coating of the cable, and for various other reasons. The current thus being so inconstant in its movement, the ordinary telegraph apparatus cannot be used. The current flowing through the cable induces a temporary current in the reverse direction on the outside of the conductor, and the attraction between the two retards the current and this retardation increases in a geometric ratio with the length of the cable. The cable becomes, in effect, an enormous Leyden jar, the wire constituting the interior, the water the

exterior coating, with the gutta-percha insulator between. When the circuit is closed, the jar is charged, and discharged when it is opened. This also causes delay. The current moves as a wave which gradually travels along the wire, appearing in different parts at successive intervals of time; and by adjusted touches of the key successive waves may follow each other through the wire before the first has died away. If the battery be too large, the cable will be destroyed; if too weak, the signal is too fleeting to be seen without prolonging the wave to such an extent as to prevent rapid transmission.

What apparatus is employed as a receiving instrument?—To overcome the difficulties of working the cable a very delicate form of Sir William Thomson's "reflecting" or mirror galvanometer is employed as a receiving instrument, which renders submarine telegraphy commercially practicable. For description of this instrument see Section XXXIII.

Explain the operation of this instrument.—In working long cables the signaling is effected by sending reversals of the current through them; one polarity of the current corresponding to the dot, the other to the dash. The "mirror" galvanometer is so constructed that the zero point is in the center of the scale, exactly opposite the mirror, and when no current is passing, the spot of light which serves as an index remains at zero. The instant a circuit is closed the magnet and mirror are deflected, and the light moves to the right or left on the scale, as the current is positive or negative. A very minute displacement of the magnet gives a very large movement of the ray of light. A movement on one side of the zero point represents the dot, on the other the dash, of the Morse alphabet, and the interval between the two the space. Before the first element has been received a second and even a third are following in its wake. To work such an instrument requires more than one operator, the receiver reads the signals and pronounces them distinctly to the second operator who writes them down; it is therefore of vital

importance that the writer thoroughly understands the reader's pronunciation of both letters and words. The operator reads the indications from a point just in the rear of the magnet and coil, the light of the lamp being cut off by the screen, so that he only sees the small luminous opening through which the light passes to the mirror, and a brilliantly defined image of the flame upon the white scale just above, which is kept in shadow by the screen.

What other apparatus has recently been employed?—A registering instrument, called the syphon recorder, also the invention of Sir William Thomson.

Explain its operation—It is so arranged as actually to delineate on paper, the apparently irregular movements of the galvanometer needle. It consists of a small glass tube, which waves to and fro over a running strip of paper without touching it. The ink is spurted upon the paper by a series of electric sparks in a fine shower, which makes a continuous line upon the paper, giving a faithful record of the motion of the current, the upward waves representing dots, and the downward waves dashes. The syphon is connected with a coil of copper wire, an electro-magnet and an ebonite disk, armed with pieces of soft iron, which, being attracted by the magnet, is kept rotating, and regulates the current flowing from the battery and the cable. Acted on by the current, the ink, as already stated, squirts from the syphon and writes a succession of dots and dashes which represent the letters of the alphabet.

What else is necessary in the operation of cables?—Condensers.

What is the speed of transmission on submarine cables?—The speed of transmission on submarine telegraph cables varies according to the length of the circuit, and the character of the conducting wire. Upon some long cables it is not more than 10 to 12 words per minute, while on others of less length and greater conductivity it reaches 15 to 17 words per minute. Some

cables, however, are capable of being worked up to a greater number of words per minute.

What is retardation?—A term applied to the inductive action which reduces the rate of signalling in submarine cables, etc.

How are breaks in the Atlantic cables located?—The resistance per mile of the cable being known, the resistance to the break is ascertained, and the location of the break can thus be easily and correctly determined.

How do magnetic storms affect the cables?—They seem to impair the electrical equilibrium of the two continents, causing earth currents to flow from one shore to the other through the cable.

SECTION XXXVII.

THE TELEPHONE.

It is said that the name "telephone" originated with Professor Wheatstone, who applied it, in 1835, to a rod of deal wood passing through several floors of a building in London, and terminating above in a large resonator, which was on the stage of a lecture hall. The first experiments in this direction were made in 1861, by Philip Reiss, of Friedrichsdorf, Germany. The sounds produced by his apparatus were very weak, and possessed only one of three essential characteristics of sound—its pitch—and therefore was not capable of transmitting articulate speech, as in the case of the present speaking telephone, invented by A. Graham Bell, in 1866, which has scarcely been improved upon, although many other forms of telephone receivers have been devised and exhibited

---

What is the telephone?—An apparatus for the transmission and reproduction of the human voice, "based upon the magnetic effects of currents of electricity flowing around magnets or bars of soft iron."

What device is used as a sender or loud speaker for the telephone? —An instrument termed the "carbon transmitter" or battery telephone, based on the principle of the microphone—the former produced in the summer of 1878, by Mr. F. Blake, and now known by the familiar name as the "Blake transmitter." This apparatus is so arranged as to vary the strength of a current of electricity passing through it ; this varying current passing through the primary wire of an induction coil, sets up in the secondary coil more powerful currents than the Bell instrument produces, thus causing louder and more marked effects at the receiving station.

What is the microphone?—An instrument discovered by Professor Hughes in 1878, who found a combination of materials that were directly affected by sonorous vibrations, which did for minute sounds what the microscope had already done for minute objects.

Explain the construction of the Bell telephone or receiver?—The Bell magneto-telephone is almost universally used as a receiver, on account of its currents being too feeble to be used as a transmitter. It is very simple in construction. The apparatus consists of a permanent magnet held by a screw in the rear; around one end of this magnet is wound a coil of fine insulated copper wire (silk covered) the ends of which are attached to the larger wires which extend to the rear, and terminate in the binding screws. In front of the pole and coil is a soft iron disk. Finally the whole is enclosed in a hard rubber casing having an aperture in front of the disk, which protects the magnet, etc. The influence of the magnet induces all around it a magnetic field, and the iron diaphragm is attracted towards the poles Any alteration in the normal condition of the diaphragm produces an alteration in the magnetic field by strengthening or weakening it, and any such alteration of the magnetic field causes the induction of a current of electricity in the coil. The strength of this induced current is dependent upon the amplitude and rate

of vibration of the disk, and these depend in turn upon the air disturbance made by the voice in speaking, or from any other similar source. It has been calculated that the current which works the telephone is about a thousand million times less than the current used in ordinary telegraphic work.

Explain the action of the carbon or Blake transmitter.—The true action of the microphone, or carbon transmitter, is very little understood; it introduces into a closed electric circuit, through which a current is flowing, a resistance which, varying exactly with the sonorous vibrations impinging upon it, causes the current to undulate in a way exactly analogous to the varying sound waves. This effect is generally assumed to be due to a greater or less intimacy of electrical contact between two semi-conducting surfaces abutting upon each other; but there is now little doubt that it is due to effects of heat generated by the passage of electricity between two points in imperfect contact, whose relative distance is variable. Carbon is the best material for the purpose—first, because it is inoxidizable and infusible; secondly, because it is a poor conductor; and thirdly, because it has the remarkable property of having its resistance lowered when it is heated—the reverse of metals.—(From a paper by Mr. W. H. Preese, recently read before the British association).

What calling or signalling device is employed?—The magneto bell.

Why is the telephone practically limited in its application?—"The difficulty of making the telephone a practical instrument under all circumstances is not due to any defects in the instrument itself, but to disturbing influences external to it, and consequent on its surroundings. The very perfection and sensitiveness of the apparatus itself are its chief enemies.

Induction is one of the greatest enemies of the telephone, and to it may be traced the greater portion of the difficulties which telephone users have in making themselves understood, though it is by no means the only source of trouble. Owing to

induction and leakage, when two or more telephone wires run side by side, what is said on one can be overheard on all the others; and when a telephone wire extends alongside telegraph wires, every current on the telegraph circuit is repeated in the telephone, leading to a hissing, frying, bubling sound that is not only very irritating, but which on busy lines entirely drowns speech."

What means have been attempted to cure this evil?—Many attempts have been made but only partially successful. The only effective mode of curing the evil at present practically used, seems to be that originally devised by Mr. Brooks, of Philadelphia, "to employ a complete metallic circuit, so contrived that the two wires are in very close proximity to each other, or that they twist round each other, so as to maintain a mean average equality of distance between themselves and the disturbing wires. When two wires of a circuit are kept at the same mean distance from the disturbing causes, however near they may be, the influence on each must be identically the same, and as the one is used for going, and the other for returning, the similar influences must be opposite in direction, and they must therefore neutralize each other." This plan is very generally used in England. Mr. W. H. Preese, electrician at the general post office, says: "The post office, having laid down many hundreds of miles on this system with perfect success, invariably constructs its circuits, both underground or overground, in this way. It is, of course, more expensive than a single wire, but the great gain—the absolute freedom from overhearing, the privacy, and the absence of crackling—is well worth the extra cost. Wires in submarine cables are invariably laid up with a twist, so that no special contrivance is needed on such wires, and in underground wires not laid up together as cables, they are, as a rule, so close to each other that twisting is unnecessary; but for overground purposes twisting is essential, and special arrangements have to be carried out. Thus, the double-wire system adopted by the post office

and by the Société Générale des Téléphones of Paris, not only cures the ill-effects of induction, but it materially diminishes the disturbing influences of earth conduction. The four-wire system of the post office effectually checks leakage from one wire to the other, for each wire of the same current is always on a different supporting arm.

Is the double-wire system effective under all circumstances?—"The double-wire system is only absolutely effective so long as the insulation is good. The moment insulation fails, connection with the earth is made, and then there are disturbing causes, due to currents flowing through the ground, which are increased in proportion to the deterioration of the insulation. Hence, good insulation is essential to telephone working."

Why is the telephone practically limited to short lines in its application?—The principal causes are due to the environment of the wires employed, the small quantity of electricity possible to generate by the power of the human voice, and because of the use of an electro-magnet for a receiver. It being well known that the element of time is an important matter in the charging and discharging of an electro-magnet, it will be readily understood that the great rapidity of these electric charges overtax its capacity. Hence, high notes are frequently lost, or so reduced in volume as to be scarcely audible.

It is said conversation has been held in America over 1000 miles; in Persia it has been effected between Tabreez and Tiflis, 390 miles apart; in India, over a distance of nearly 500 miles; In Australia, of 300 miles; but in all these cases it was done either at night or under exceptional circumstances, and in all cases the wires were overground. Had they been underground or submarine, the case would have been very different.

Why is the speaking distance practically limited on underground or submarine cables?—Mr. W. H. Preese gives the following reasons, which are probably correct: The reason of the diminution of speaking distance is due to the electro-static capacity of the telegraph line, which absorbs the minute quantity of electricity that makes up the currents employed for

telephonic purposes. In every submarine cable, before a signal can be made at the receiving end, the whole cable must be charged up with electricity, and if there be not sufficient electricity sent in to effect this purpose, practically no signal appears at the distant end. With telephone currents on long cables, the whole of the electricity is, as it were, swallowed up—that is, none of it appears at the distant end, or, if it does appear, it is rolled up in one continuous wave, bereft of those rapid variations that reproduce sonorous vibrations. The use of underground wires very seriously impedes telephonic extensions, and with our present apparatus and present knowledge we cannot readily speak over greater distances than twenty miles.

What system is universally used in carrying out telephone operations?—The "telephone exchange" system, whereby any subscriber may be placed in communication with another.

Is the telephone adapted for regular telegraphic business, and is there any probability that it will supersede the ordinary telegraphic apparatus?—With the present apparatus and mode of working, the telephone is not adapted for regular telegraphic business, and is not likely to supersede the ordinary apparatus used in telegraphy. Although in Germany it is used very extensively for telegraphic business, and to some extent in this and other countries. But there are many reasons why it is not practicable, so much so, that the Western Union Telegraph Company accepts messages for telephone offices *only at senders' risk.* Speed is everything in the telegraph. We can telegraph much faster than we can speak, and this is of more importance than speech; hence any device that retards speed can *never* take the place of the telegraph apparatus; besides this, is its liability to error, and it not being practically possible to secure that privacy which the telephones require. The telephone, however, is very rapidly gaining ground, and as improvements are effected in it and its accessories and mode of working, its use will still further extend.

PART FOURTH.

COMMERCIAL BUSINESS.

Statistics show that the growth of the telegraph business all over the world is something extraordinary; the telegraph system has become to the world's inhabitants what the nerve system is to the human body. To destroy it would be to paralyze commerce, and reduce the traffic between nations one-half. The telegraph and ocean cables have become the great channels for conveying intelligence, and the medium through which the commercial and financial transactions of the world are carried on. The number of messages now sent is vastly superior to that of a few years ago, despite the enormous telephonic communication.

The total length of the wires of the world, including submarine cables, is now 1.510,592, over which more than one hundred and forty million messages per annum are being sent. "There are 70,928 miles of submarine cables in successful operation, completing the girdle about the world, and conveying millions of messages a year. This is the growth of a generation, and, almost incomprehensible as it may seem, it is doubtless but the beginning of what is to be. It is beyond the limited power of

man to predict the part telegraphy will play in the world's future."

The commercial telegraph business of this country is principally done by the Western Union Telegraph Company, which according to President Green's last annual report, now controls over 400,000 miles of wire, and over 12,000 offices, and sent the past year 39,000,000 messages, not including messages sent over wires leased to the press and to brokers, and a very large number of messages sent for railway companies, of which no account is taken.

This combination of the electric industry thus represents a vast capital, and must be regarded as the largest and most powerful private telegraphic organization in the world. "Its board of directors includes a larger number of wealthy and successful men than can be found at the council table of any other company in this country, or, indeed, in the world. Aside from the individual worth of these directors, estimated at from three to four hundred millions of dollars, they administer and control interests representing in the aggregate infinitely greater sums, employed in all the methods of transportation, and in every mercantile pursuit. In short, with a few exceptions, the directory is a body of magnates such as has never before been got together in the management of one enterprise."

The stalwart form of competition, however, is rapidly pushing to the front in opposition. And what the future may wit ness in telegraphic development, it is impossible to foresee.

"The United States originated the telegraphic system and is still in the lead, according to the testimony of Mr. Pender, an English member of Parliament, and probably the best living authority on the telegraphic systems of the old world. He has just finished a thorough inspection of our system, and says there is none any place more thoroughly conducted or better calculated to meet public requirements. More messages are sent to each one hundred inhabitants in the United States than in any other

country in the world except England, where the telegraphic system is under the control of the government the same as the postal system. From this standpoint it looks as though the time will come in the near future when a great bulk of the world's intercourse will be by telegraph."

The information compiled regarding commercial business, has been carefully selected from a large amount of material, gathered together from official sources, as well as from the experience of efficient operators in all grades of service, and it is therefore submitted as *complete*, trustworthy, and comprehensive as brevity will permit.

SECTION XXXVIII.

MANAGEMENT OF COMMERCIAL OFFICES.

Main offices—.In cities the main office is generally divided into two departments. The receiving and delivery department in the basement and the operating room on an upper floor.

The manager.—Each office is in charge of a manager, usually appointed by and under the jurisdiction of the district superintendent, to whom he is accountable for the proper performance of his duties, and those of his subordinates.

The working force of a large office—Consists of the following: The manager, the cashier, the bookkeepers, delivery and receiving clerks, chief operator and assistants, the traffic chief, the operating force, the messenger service, and the battery or general utility man.

Managers of branch offices.—They are, in the same city or town, unless otherwise especially arranged, required to report to the manager of the main office therein, to abide by all the rules and regulations respecting the ordinary transactions of the business

of the main office; to produce daily all messages which have been sent, copies of all messages received, and account to him, daily, for all moneys received in the transaction of business.

Responsibility of managers.—They are held responsible for all property belonging to their offices, and are required to exercise great economy in the use of all supplies, and are responsible for all money received and disbursed, except when a cashier is appointed for the purpose, who in such cases is held responsible for the money.

Receipts.—The funds of the company are held subject to the order of the treasurer, who designates places of deposit.

Deposits.—In every place where there is an incorporated bank in good standing, and which has been designated by the treasurer as a place of deposit, the manager is required, unless otherwise directed by the treasurer, to deposit in such bank, daily, all the cash on hand at the close of banking hours, in his name as office manager of the company he represents, and should make arrangements with such banks, if practicable, to provide drafts on New York, for their monthly balances, without charge.

Remittances.—All balances due from offices must be remitted to the treasurer at the end of each month, unless otherwise specially ordered by him. No balances should remain unpaid, but each month's business must be promptly closed up and settled by itself. Remittances to the treasurer must be made through the mail by draft on New York, payable to the treasurer's order, by all managers who are able to obtain New York drafts without expense. Managers in places where banking arrangements cannot be effected, are required to remit either currency by express or postal money orders by mail, as shall be most economical, and an explanatory letter *enclosed with every remittance* stating on what account it applies.

Expenditures.—Managers of offices are prohibited from purchasing or paying out any money for office furniture, repairs of

office, or anything therein, stationery or supplies, or for any other purpose except to pay fixed monthly salaries of employes, rent of offices, light, and fuel.

Any outlay for fitting up, re-fitting, furnishing or re-furnishing of any office, must be made only by special approval of the district superintendent, who is required to have the sanction of the general superintendent for such expenditures.

Salaries.—Salaries are paid monthly, at the close of each month, and no increase is allowed unless previously authorized by the general superintendent.

Vouchers.—A voucher for every authorized expenditure, written upon the blank form provided for this purpose, numbered to correspond with its entry on the monthly account current, and made out so as to fully and clearly explain itself, must be sent with the account current to the district superintendent.

Every voucher should be written with ink and signed by the person to whom the payment is due. Vouchers receipted by "his X mark" must be witnessed by some person other than the one disbursing the money.

Requisitions for supplies—are required to be made on the proper blank provided for that purpose once in *three months*, and should be carefully estimated and forwarded to the proper official.

Material not in use.—All instruments, relays, keys, switches, or parts of the same not in use, and all refuse zinc and copper from main or local batteries, and all old books, messages, or other material on hand, must be reported to the superintendent every quarter.

Office hours.—A competent person to receive messages from the public is required to be in attendance at 7 o'clock A. M. from March until November, and as early as 7:30 o'clock during the winter, and 9 to 10 A. M. Sundays unless otherwise ordered. In cities principal offices are kept open daily—day and night.

The office hours assigned each employe are arranged as the service requires, and absence from duty within these hours is not permitted, except by authority of the superintendent, and in all cases deduction is made for loss of time.

Holidays.—On the national holidays of the year, as the Fourth of July, Thanksgiving, Christmas and New Year's Day, the hours of service are usually from 8 to 10 A. M., and from 4 to 6 P. M., except at repeating stations and principal offices, which keep open as usual, but with such diminished force as may be sufficient for the service.

Whenever a manager vacates his office during the month, he must make up his accounts and pay over to his successor all funds in his hands, and send to his superintendent a report of such settlement, made up on the proper blank form, with the receipt of his successor for money paid and property delivered.

SECTION XXXIX.

THE OPERATING DEPARTMENT.

Regulations.—All persons employed in the operating department must conform to such regulations as the manager may deem necessary for the prompt and proper transaction of business.

Chief operators.—The chief operator is intrusted with the ordinary working of the lines, testing and changing of circuits, and the directing of operators and repairers.

Office calls.—Every telegraph office has a different name or call on the same circuit, which usually consists of one or two letters ; these calls or signals are made use of in arresting attention of the different stations as desired. Thus, the call for New York is N. Y.; Cleveland, H. If New York desires to communicate with Cleveland, he repeats the latter call on the line until

answered. It is proper to sign one's own office every three or five calls, so that others may know who is using the wire.

If Cleveland hears the call, he opens his key, and answers by repeating "i" several times, and signing his own call.

When so answered, New York proceeds with his business. The process is exactly the same between any other two offices.

Writing one's own office call.—This is termed "*signing*," and must be done *once* and *only once* at the close of *everything* that is written over a line, be it calling, answering calls, giving "O K," sending messages, or conversing.

Caution.—Before opening a key to call another station, adjust the relay carefully, particularly in wet weather, to make sure that no other office is using the line, and in calling another office, care must be taken to see that the relay is *adjusted* to receive the acknowledgment.

Contesting for circuit.—This is strictly forbidden, and any operator guilty of it should be promptly reported to his superintendent by any person having knowledge of the fact.

Testing.—At all offices where line repairers are stationed, an operator must be on hand, before the departure of the first morning train, to test the wires, and in case of faults, to direct the repairer to place the lines in working order at the earliest practicable moment. The circuit manager or chief operator at all terminal points, is required to test the wires thoroughly and have the circuits arranged for business by 7:30 o'clock A. M., and operators at intermediate offices must report to, and promptly obey, all instructions from the circuit manager in regard to the working or testing of the wires.

No admittance to operating rooms.—In order to preserve the strict privacy of all messages, no person, unless in the employ of the company, is permitted to enter the operating rooms or other private offices, except upon the written permission of an officer of the company.

Closing offices temporarily or for the night.—Intermediate or way offices are not permitted to close for the night without first clearing their files, ascertaining from the nearest repeating offices if there is any business for them, and exchanging "G N" (good night) therewith.

When any office is closed temporarily, or for the night, instruments must be cut out of the circuit, and the switch or cut-off examined to make sure that the circuit is complete through it.

SECTION XL.

MESSAGES.—GENERAL INFORMATION.

The regulations governing the service of a telegraph company are intended for the protection of its interests, and not to repel business offered; but rules cannot be framed to meet every question which may arise, therefore whenever the letter of a regulation cannot be met, an intelligent interpretation of its spirit becomes a duty.

Telegraph message.—A telegraphic communication sent from one person to another similar in form to that of letters.

Messages, how divided.—Messages may be divided into *five* parts, viz.: check, date, address, body, and signature.

The check.—The check immediately precedes the date, and gives the number of words in the message subject to tariff. It aids in preventing omissions and errors. The check also tells whether a message is paid, collect, or free,—if free, it usually explains why.

The date.—The date is composed of the name of the place where the message originates, the month, the day of the month, and the year. An operator accepting a commercial message for transmission, should be careful that this is written out in full.

In actual transmission, the month and year are always omitted. It can do no harm to write the name in full, and the date should always be given in commercial business. This is always done when the message goes beyond the line where it originates. In sending a message, the date is always prefixed by "from" abbreviated to Fm. or Fr.

Sometimes on the same line the office call is only given, instead of spelling out the name of the place.

The Address.—Messages must bear one clear and sufficient address to a single person or firm, together with the street, number and place of its destination, which will not be counted or charged for. A single message addressed to two persons for separate delivery is refused. Where a message is addressed to two or more persons for delivery to one only, all names except the first is charged for. An address to Mr. and Mrs. ——— will be accepted as a single address. The number of a street in an address should be written in words. The word "to" always precedes the address, and a period divides it from the body of the message. When the office to which a message goes is on the same line, usually only the office call is written, but when the message goes through, the destination is spelled out in full. No message must be accepted addressed to any person at a specified telegraph station with directions to transmit, if absent, to any other station. In such cases two messages must be sent, one to each place.

The body.—The body is embraced between the period and signature. No abbreviations are permitted, or if inserted, each letter is charged for; compound words are usually considered one word.

The signature.—The name of the person or firm, sending the message, and in transmission is always prefixed by *Sig.*, which enables the receiving operator to place the signature in its proper place on his copy.

Tariff books and the Journal of the Telegraph.—Each office is

furnished with a tariff book, giving the rates; and the Journal of the Telegraph, the official paper of the Western Union Telegraph Company, is forwarded monthly to all offices of that company, and managers are required to carefully read and study all executive orders printed therein, and note same in their tariff books, also to carefully note all changes of tariff, names of new offices opened, and offices closed, and such answers to correspondents as improve or modify existing regulations, relating to the transmission and handling of commercial business.

Rates, classification of.—The Western Union rates are local, special, square, State and night rates.

The local and special rates are exceptions to the square and State rates, and are given by special instructions through the district superintendent's office, or direct from the tariff bureau to the offices between which they apply.

Rates, how ascertained.—To ascertain the rate to a Western Union office, to which there is no special or local rate, note first the number of the square before the name of the office, and then *refer to the tariff sheet*, showing square and State rates; if there is a rate to the number noted, which is less than the State rate to the State, Territory, or Province in which the office is situated, the square rate will be the rate desired. If there is no rate to that number, or if the rate given is higher than the State rate, then the latter will be the rate desired.

To calculate the tariff to a point on another company's line.—Find the rate to the transfer office, and add to it the rate between point of transfer and point of destination, for the full tariff; always check the transfer office. When a message passes over one or several lines, the charges must be *all* prepaid or *all* collect.

Government rates.—A special rate on Government messages between the officers and agents of the United States, of *one cent per word* (except the name of the place where the message

originates and the date) is charged for each circuit of 500 miles via the shortest practical route. In computing circuits, if there is one or more circuits and a fraction of a circuit, such fraction is deemed a circuit, and any distance less than 500 miles is deemed a circuit. When the rate computed exceeds the ordinary rate charged the public, then the Government rate is not applied. All messages of less than twenty-five words, address and signature included, is rated as if containing twenty-five words, and all messages exceeding twenty-five words is rated by the exact number of words they contain, address and signature included.

System of Checks.—The former custom of transmitting the amount of tariff on a message has been abandoned by most companies, except in cases where a message comes collect, from a foreign line, to be forwarded. The tariff for each line is then given in the check, thus—10 collect 50 and 50.

By the new system, both the sending and receiving operators calculate the checks, and enter it on their message and books.

EXAMPLES :

For a paid message of nine words, the check should read : 9—Pd.

For a collect message: 9—Col.

For a free message on account of pass: 9, pass, No. 101. (Number of pass not transmitted.)

For a free message, account of operator—9, Dh., operator.

Basis for counting words.—Ten words is the basis. Upon full paid business, ten words can be sent as cheaply as one, but for all over ten, an additional rate (per word) is charged. The date, address and signature of a message are not counted. The body of the message is always counted.

Charges.—Every message must bear the signature of the person or firm sending it, which is not counted, or charged for. Additional signatures, addresses, and all other words after the

signature must be counted and charged for, *if to be transmitted.* In all such cases receiving clerks should inquire whether transmission is desired, and if not, the added words should be erased, but in such manner as not to entirely obscure them. When there are several distinct signatures, all but the last one are counted and charged for. When extra words occur after the body (regular signature excepted), the number of such extra words must be given in the check. Titles, however, not exceeding two words, such as cashier, president, manager, chairman, general superintendent, chief police, etc., are not charged for. In messages sent collect, the word *collect* must be counted, but not charged for. Upon night or "red" messages the same rule applies.

Rules for counting words.—Names of cities and places, when used to designate such cities or places, are counted as one word; for example, New York, New Orleans, West Troy, United States.

Names.—Names of persons and places, initial letters, titles, etc., when given to things, are to be counted according to the number of words or distinct separate signs used to express them. The prefixes, O, Mc, Van, Von, De, Le, La, are regarded as forming a part of the word following them; as McGrigor, O'Connor, DeWitt. Each initial is counted as one word, except A. M. and P. M., meaning respectively forenoon and afternoon; C. O. D. and F. O. B. are each three words.

Words connected by a hyphen, found in dictionaries, composed of two or more distinct words, as forming a single word, are counted as so many different words, and no hyphen will be accepted as forming a part of any word or message. Example—*man-of-war*, three words. The words *today*, *tonight*, *tomorrow*, *railroad*, *railway*, *anyhow*, *anywhere*, *anything*, *everything*, are recognized English words, and are to be counted as such, unless separated into distinct words by the writer. The words *dont*, *wont*, *cant*, *shant*, although not correctly written without the use of apostrophes, are in common use, and may be received as one

word when no apostrophe is employed. The same rule will apply to contracted words, or words in the possessive, such as *Eddies*, *Cousins*, *Edwards.* If such words are written as in the expression "Hope Eddies well," they will be sent as one word. In some instances, however, the custom of operators has made the exception a better guide than the rule.

When messages contain amounts, dates, or numbers, the sender should be requested to write them plainly in words. If such amounts, dates, or numbers, after being written in words, be also duplicated in figures by the customer, such figures must be counted as part of the message, according to the number of words employed to express them, and included in the check and paid for. Figures are, however, allowed in the free date of a message.

Code messages.—A code message is composed of words found in ordinary dictionaries or gazetteers, but disarranged, or having a secret meaning. Such messages are transmitted at ordinary tariff rates.

EXAMPLE.

(Check) 7 paid. Cleveland, O., Dec. 12, 1882.
(To) Robert Smith.
New York.
Lenity nervous Madrid powder Dolores publish, Mexico.
(Sig.) Brown & Co.

Cipher messages.—A cipher message is composed in whole, or in part, of figures, letters, characters, or words not contained in dictionaries or gazetteers, or a combination of either, or all, having no sense unless interpreted by means of the key in possession of the sender and receiver.

EXAMPLE:

(Check) 15 paid, cipher. Cleveland, O., Dec. 12, 1882.
(To) Robert Smith,
New York.
Lenity 23456 hgbcmo 72k3 powerful bcdefgkrmna 9397368.
(Sig) Brown & Co.

To count cipher messages.—In cipher messages, count first the number of words in each group allowing three figures or letters to a word, thus: in the first group given in the example, the figures "23456" count as two words: the letters "hgbcmo" count as two words: the group "72k3" count as two words; the letters "bcdefgkrmna" count as four words; the figures "9397368" count as three words, in all thirteen. To the number thus obtained add the ordinary words ("lenity" and "powerful") in the message, making in all fifteen words.

Marks of punctuation if intended for transmission will be included in the count, as if they were figures or letters.

The word cipher should appear in the check as in the example.

No extra charge will be made for cipher messages.

In ordinary messages the receiving operator has the context to help him to make out imperfectly transmitted words, but in code and cipher messages *every letter* must be transmitted with exactness.

Telegraph bulls.—Telegraphic errors, blunders, mistakes in messages.

Information respecting messages.—Managers of offices must give no information respecting messages or their contents, or by whom they have been sent or received. Ingenious questions are sometimes asked to draw out information, to be used for improper personal advantage, or to the injury of others. All questions, therefore, such as, "Has A. B. sent a message?" "Was the answer to E. F.'s message all right?" "Did C. E. get a message this morning?" must not be replied to.

Privacy of messages.—All messages, including press reports, must be treated as strictly confidential, and must not be shown, nor any information given respecting them or their contents, except those to whom they are addressed, nor make the contents of messages the subject of conversation or remarks.

Neither must the books or papers be examined by any person

not connected with the company, except by order of an executive officer.

The executive committee of the Western Union Telegraph Company recently adopted the following resolution: "Any officer, clerk, operator, or other employe handling messages, who shall report or divulge the contents of such messages to any officer of the company, or other person, shall be promptly dismissed from the service of the company, and prosecuted under the law, making it a penal offense to divulge the contents of messages.

Penalties for divulging contents of messages.—The following are the provisions of the new penal code:

§ 641. A person who, either

1. Wrongfully obtains, or attempts to obtain, any knowledge of a telegraphic message by connivance with a clerk, operator, messenger, or other employe of a telegraph company; or

2. Being such clerk, operator, messenger, or other employe, wilfully divulges to any but the person for whom it was intended, the contents of a telegraphic message or dispatch intrusted to him for transmission or delivery, or the nature thereof, or wilfully refuses or neglects duly to transmit or deliver the same, is punishable by a fine of not more than one thousand dollars, or by imprisonment for not more than six months, or by both such fine and imprisonment.

§ 642. A person who wilfully and without authority, either

1. Opens or reads, or causes to be opened or read, a sealed letter or telegram, or

2. Publishes the whole or any portion of such letter or telegram, knowing it to have been opened or read without authority.

Is guilty of a misdemeanor.

Forged message.—In many of the States there is a severe penalty for forwarding a message known to be forged.

Jury duty.—As a rule, operators actively employed are free from military and jury duty.—*Journal of the Telegraph.*

Furnishing copies of or certifying to correctness of any message.—All managers and other employes are *strictly prohibited from*

furnishing copies of original messages, or from certifying to the correctness of any message, or copy thereof, whether sent or received.

When the *sender* or *receiver* of a message applies in person, he will, if known, or properly identified, be permitted to see or make a copy of his dispatch for himself. When the application is in writing, the signature must be identified as the genuine signature of the person, or firm, who sent it, precisely as if it were the signature of a bank check or draft. In no other case will such permission be allowed, without the order of an executive officer.

Payment of messages.—All messages, except answers or covered by a pass, must be *prepaid*, unless *guaranteed* by a responsible party. Messages on the business of the party sending, and answers to collect messages must invariably be prepaid. Messages addressed to hotels or to parties absent from home, must be prepaid in all cases, unless they are answers to messages, marked answer prepaid. Transient persons sending messages which require answers, must deposit in advance an amount sufficient to pay for a reply of ten words. Usually a charged account is kept with reliable business firms, and payment made monthly.

Profane or obscene language.—Messages containing profane or obscene language are not received for transmission.

Office messages.—Office messages are used to assist in the prompt transaction of business and correction of errors, and have preference over any other business; but they must neither be needlessly sent nor contain unnecessary or superfluous words.

Night or "red" messages are such as do not require, and are understood by the senders not to require, delivery until the following day; or, such as when received on Saturday, delivery is not expected until the following Monday. Such messages must be written upon the *night message blanks*, under and subject to the conditions printed thereon, and may be accepted from the

public any time during the day, *to be transmitted at night*, at a fixed rate considerably less than day rates; but when the day rate is less than twenty-five and two, the night message rate is the same as the day rate.

Red.—These messages are called "red" because the blanks are printed in that color to distinguish the night messages from ordinary business.

Check errors.—A great source of discrepancies between offices arises from "*check errors*," and checks being changed in the transmission of messages.

The first effort, on the discovery of such an error, should be to collect the charges at one of the offices concerned. This can usuallv be done, if action is taken when the error is first discovered.

Monthly error sheets.—Each month the auditor of the company gives notice of check errors. When an office receives an error sheet, the books and files must be carefully examined, and if no errors are found, a statement must be made and sent by mail to each office with which they differ. And on receiving such a statement from any other office, the same must be compared with the books, and where a disagreement is found, the "signature," "address," and "check" of messages causing the difference must be given, and the same returned to the office from which the statement was received, with such explanations as can be given. A memorandum of all correspondence concerning errors, should be kept. This may be conveniently done, in most cases, on the margin of record sheets. The wires should not be used in settling errors, except in extreme cases. Postal cards may be used with much advantage, but addresses and signatures of messages must not be written on them.

Statements regarding errors.—The statement that such a message was "received paid," or "sent collect," is not accepted as a satisfactory explanation of *a* "*deficit*," but a full written state-

ment of all the particulars, accompanied by the copies of the message, are required, and the error sheet returned to the superintendent as soon as possible, with the explanations, or money, to cover the deficits. Explanations should be written in ink, on a separate sheet, and accompanied by the statements of the disagreeing offices, as vouchers.

Abbreviations are used in conversation, office messages, railroad business and news reports, and are usually made by dropping out the vowel sounds, and leaving the consonant skeleton. Some are, however, entirely arbitrary. They are, however, easily acquired in actual business.

Free messages.—Annual franks are issued to certain persons who are entitled to send messages free. These franks are of two classes, viz: the business frank and the complimentary frank. Each frank is numbered, and states on its face the name of the person to whom it is issued, the class of messages, limit of territory, and period of time it is valid.

The business frank designates upon its face the particular kind of business to be sent free.

The complimentary frank entitles the holder to transmit brief messages of a domestic or social character to his family and friends, but does not cover any description of business, political or other messages.

Free messages on account of franks.—When such messages are presented, the frank must be shown and examined, and the number noted on the message directly after the check, but not sent over the line.

Free messages without franks.—Official messages, private messages of an urgent social character by employes (approved by the manager of an office), and messages on railroad business on the line of the road, except for points beyond the line, which require a pass or to be paid for.

Record of free messages.—All free messages must be entered

daily on a blank record sheet provided for the purpose, and at the end of the month a free message report made out and sent to the superintendent, including the original messages; and the amount of tariff which would have been chargeable, had the message been paid for, and the reason for sending free, must be endorsed upon each message, except official business and messages upon railroad business between local points on the line of any road.

Preserving messages.—All messages must be carefully filed, so as to make reference thereto easy and expeditious. Each day's business should be kept separate, and every message marked with a number corresponding to its number in the Register Book. Each day's business, plainly marked, should be enclosed together and labelled. These packages must be retained at least two years, after which they will be disposed of as the superintendent may direct. Any use of old messages by which their contents are, or may be, exposed to the public, or otherwise than herein directed, is absolutely forbidden.

The Western Union Telegraph Company, "money orders" by telegraph.—For the accommodation of travellers and others, in emergencies, and incidentally to facilitate its own business, the Western Union Telegraph Company will make transfers of money, in small amounts, containing no fractions of a dollar, between a limited number of its offices. Only principal offices, or offices which are designated as money order offices, are permitted to do this kind of business. The system is simple; thus if a party in Cleveland desires to send money to New York, he deposits the amount in the Cleveland office, pays a slight percentage, notifies the party in New York, and the company there pay out the funds to whoever directed, cipher dispatches being used, and precautions taken that guard against imposition. Nothing but cash is received, and the business conducted on a purely cash basis.

Charges.—To cover clerical and incidental services, a charge is made of one per cent. on all sums of $25 or over, and for smaller amounts such charge is 25 cents in each case.

As the usual telegraphic service necessary for each transfer exceeds two telegrams of 15 words each, a further charge is made for this service of a sum not exceeding double the tolls on a single message of 15 words between the transfer places.

Money transfers can also be made between the transfer offices of this company and the transfer offices of the Great North Western Telegraph Company of Canada. The charge for each transfer is two per cent. on all sums of $25 or over, and for smaller amounts, 50 cents in each case, and double tolls at regular day rates on a single message of 15 words between the remitting and paying office.

Payment of the sums transferred.—Payment is made at the principal office of the Telegraph Company at the point designated, upon satisfactory evidence of the personal identity of the payee. The sending of a telegram requesting transfer of money to its sender will not be sufficient evidence of his identity with the payee of such transfer.

In case payment is not made to the payee within 48 hours after receipt of the transfer message by the manager of the paying office (exclusive of Sundays and holidays), the transfer will be cancelled, and the amount thereof refunded to the sender on application at the receiving office, and in such case the amount received for services and tolls will be retained by the telegraph company.

In cases where an applicant desires to transfer money to a point at which there is no transfer office, but which can be reached from a transfer office in its vicinity, by express or other transportation company, the proper course to pursue would be to explain to the applicant that the company cannot undertake to pay out money at points where it has no transfer offices, and that the only way in which he can accomplish his object will be to make the order payable to the express or other transportation company, direct, and send a separate paid message of instructions, as to the disposal of the funds to such

company. This will relieve the telegraph company from all responsibility beyond paying the money to the company as payee in the application and taking its receipts therefor.

Associated press reports.—A large proportion of the night work in cities consists in receiving the associated press dispatches; a combination of wires is so arranged that a large number of cities receive the reports simultaneously. These are copied on manifold paper, enabling the operator to make the required number at one writing, and these copies sent as rapidly as received directly to the newspaper offices, where they soon find their way into print.

Explain the character and mode of operation of the associated press.—The associated press is practically a central news exchange, with branch associations for local purposes in various cities, all governed by the same object, of getting the most and freshest news, while the cost of distribution is divided among all the members. The branch associations collect the news within their respective territories and forward it to New York, whence it is redistributed by telegraph all over the country among the voting members and customers not members.

United States signal service weather reports.—By arrangement with the telegraph companies, a system of telegraphic circuits for the transmission of weather reports, is formed at a stated hour each morning, afternoon, and midnight, connecting certain defined places, to be worked without relaying, which has the effect of converging the reports at the same instant of time, by various paths upon the central office, "Washington," where the synopsis and indications are made up, and distributed from the telegraph rooms of that office through the associated press to the signal observers in the different commercial centers of the United States, and to the public press of the country.

Reports of stock, cotton, and produce quotations.—These quotations, sporting news, and items in regard to financial and commercial changes, gathered at all the most important centers of

information in the United States and Europe, through the agency of experienced reporters of the Gold and Stock Telegraph company, are transmitted over the wires of the Western Union and Atlantic cables, and furnished, by means of printing telegraph instruments, called the "ticker" or "stock indicator," to boards of trade, exchanges, chambers of commerce, hotels, and private subscribers, at their places of business.

SECTION XLI.

TRANSMISSION OF MESSAGES.

Blanks for transmission.—All telegraph companies require messages for transmission to be written upon the printed blanks under the conditions on which the company transmit all messages. Whenever this is impracticable, the operator must attach it permanently to the face of the blank, so as to leave the printed heading in full view immediately above the message.

When requested, operators can write the body of messages, but are not permitted to transmit them unless left in writing and signed by the person or persons sending them. If the address of a patron is not known, it should be secured in order to facilitate delivery, etc.

Reception of messages for transmission.—All messages presented for transmission should be *carefully read to the customer*, and every word clearly understood by the receiver. If the address is insufficient, a more complete one giving street and number, or occupation, should be requested. All abbreviations should be avoided, and anything likely to be misunderstood or liable to occasion error in transmission, must be made perfectly plain before it is accepted for transmission. When a message contains words incorrectly spelled, the receiver should courteously call attention thereto, and endeavor to have them corrected. This must be done discreetly, to avoid offence, but is

important, to prevent error in transmission. When the message has been duly accepted and paid for, *the time of its reception must be noted on the blank, with the initial of the receiver.* The number of words, amount of tolls and the word paid, collect, or free, as may properly designate the message, must also be noted thereon. Operating rooms in cities are always private, receiving clerks in separate offices, transacting business with the public.

Transient patrons.—"Transient persons sending messages which require answers, must deposit in advance an amount sufficient to pay for a reply of ten words. In such cases, the signal "33" should be sent with the message, signifying that the answer is prepaid." In all cases when a party offering a message containing a greater number than ten words, as a prepaid answer, the receiver should notify the party that such excess was beyond the limit and must be prepaid, or a sufficient guarantee be given to secure the company from loss. In cases where a party offers a message for transmission, pertaining to his own business, which reads as though an answer was required, but states that he will not pay for an answer, should any come, the proper course to take, will be to send the message, and with it an office message stating that no answer was required, but if one was offered, to require that it should be prepaid.

Deposit for a "prepaid answer"—length of time before returned.—Where parties have deposited money for an answer, and none is received within a reasonable time, an office message should be sent to the office to which the original message was addressed, stating that the party who has deposited the money for an answer demands the amount returned, and that, unless the answer is received within a specified time, it will be returned, and that your office will not be responsible for the tolls upon the answer after such a time. But the money deposited must not be returned until it is certain beyond a doubt that the office from which the answer is due understands that the prepayment is withdrawn.

Order of transmission.—"Messages received for transmission are forwarded in the order in which they are received, with as little delay as possible—hence the questions: When will this message be sent? Will this message be sent at once? or, Please rush this, can only be answered by the above statement." Managers and receivers are strictly forbidden to make any *promise of transmission or delivery* of any message under any circumstances, beyond the assurance that due diligence will be used in forwarding to destination.

Messages transmitted as written.—Messages must be sent as they are written. And to follow copy is the only safe rule. Corrections can only be made in the presence of the sending party. The subject, however, is one which appeals to the intelligence of a manager.

Where periods and other punctuation marks are used, care must be taken to transmit them precisely as in the original When obscure or difficult words occur in messages, the transmission must be slow and distinct, and the obscure sentence or difficult words repeated after the signature. Great caution should be used in the transmission of proper names. They should be written slowly, and double the usual space left between the initials. Words containing spaced letters, like C, O, R, Z, should be transmitted with caution, and such letters made plain, separate and distinct.

Messages to be forwarded.—When a person expecting a message at any office is obliged to leave such office before its arrival, and desires it to be forwarded to him at another office, the tolls thereon, except in the case of well known and responsible persons, must be prepaid. Whenever messages which have come over the line of any other telegraph company are offered at points not indicated by the tariff book as the proper place for such business to reach the lines, or whenever messages are received by mail at any office to be forwarded by telegraph, or in case a person having received a message requests the same

to be forwarded to any other place, or in case a person leaves town before the arrival of an expected message, and it is forwarded to him, or whenever under any circumstances a message is to be sent from any office, bearing a date other than that on which it is sent, or place from, other than that of the office from which it is forwarded, the name of the place where it originated and the date must be charged for.

EXAMPLE.—If a message from Buffalo, Nov. 15, to Cleveland be received after the party addressed had left town, and a request made that it be forwarded to Cincinnati, the date of the message would be sent as follows: "BUFFALO, Nov. 15, *via Cleveland, Nov.* 15." Thus adding in and charging for, as a part of the message, the three words and figures, "*Buffalo, Nov.* 15."

Responsibility of operators in sending messages.—A careful and correct style of transmission is of far more value than mere rapidity. Operators are held responsible for the correct transmission of all dispatches entrusted to them. They will therefore see the necessity of exercising the utmost care in reading the original messages correctly, as well as in accurately transmitting and copying them. In the transmission and receiving of messages, operators are to assume nothing.

Messages between employes and upon company business.—These are sent without checks and with much less formality than commercial messages.

Duty before sending a message.—Call the office and receive a response.

Order and form of the transmission of a message.—1st. The number. — 2nd. The initial of the operator sending. — 3d. The check. — 4th. The place from, and date. — 5th. The address, followed by a period. — 6th. The body of the message. — 7th. The signature, followed by address (if any) of signature, or any other special directions.

EXAMPLE:

Form of ordinary message as it should be received from the customer.

Cleveland, O., Jan. 17th, 1883.

To Chas. Jones,

Palmer House, Chicago, Ill.

Books sent by American Express. Please accept thanks for order.

John Smith.

As transmitted:

No 1--J—10 Pd (* Fr) Cleveland O 17

(* To) Chas Jones

Palmer House Chicago Ill.

Books sent by American Express. Please accept thanks for order.

(* Sig) John Smith

(* SY)

(* Not copied by the receiver.)

Endorsements.—The number, time sent, and initials of both the sending and receiving operators must be endorsed on the message as soon as sent. When two or more messages are sent, one after the other, this is usually done with the *left hand* while sending with the right; sometimes "ahr" is given at the end of each message to give the receiving operator warning that another follows.

Acknowledgment of a message when sent.—When an operator is through sending a message, or messages, the receiver acknowledges the same by "OK," his initial letter and office call, or commences to send back business. No message is regarded as sent without this acknowledgment. If it is not given the sending operator will call the office again, and when a response is given, ascertain the cause, then if the business was not received OK, he will repeat it.

The origin of "OK."—"The initials or letters 'OK,' employed as a signal in telegraphic practice, were derived from the politi-

cal campaign of 1840, when the words 'Oll Korrect'—represented by 'OK'—were in universal use in speeches and in the press.

"As the response to the reception of a message, Morse employed the letters 'i' 'i,' but the everyday slang, 'OK,' used on all occasions, was readily employed by the telegrapher. Besides, the letters 'OK' are more distinct, telegraphically, than 'i' 'i' for signals. Though in use from the commencement of the telegraph as a signal, they were officially adopted by the Telegraphic Convention at Washington in 1853."—*Shaffner.*

Transmission to repeating or principal offices.—In order that the operator at such offices may copy upon the proper blank provided for repeated or city business, messages sent must be prefixed by "Thru" or "City."

Prefixed words, to give warning of the kind of message to be sent to an office.—

Govt.—Government message.

Red—Night message.

Long—Message containing many words.

Rush—Important message, requiring haste.

9—Important, has preference over everything.

Stocks—Stock business important.

Special—Press message.

Cypher—Cypher message.

Code—Code message.

Ofs.—Correction of errors, or pertaining to the business of the company.

"*Relaying*" *a message.*—This means to receive it from one point and transmit it to another. The term "relay" covers the whole service.

In reporting the number of "relayed messages" a relayed message should be counted *as one* and not as two messages.

Example of ordinary office messages.—If the address of a message from New York to John Wilson, Chicago, should be

received in such shape that the party could not be found, Chicago would send the following: office message.

To New York Office:

Give better address, Wilson, signed Harding, of tenth.

Chicago Office.

To this message New York might reply:

To Chicago Office:

Cannot give better address, Wilson, signed Harding, of tenth.

New York Office.

If New York had given a wrong address in first instance, he might reply:

To Chicago Office:

Find Wilson at thirty-two State, instead of twenty-two, message of tenth, signed Harding.

New York Office.

Numbering messages.—When companies number messages, they are numbered from the sending office to the receiving office, on the same circuit only. For example, if Buffalo, in sending Chicago messages, has to send to Cleveland for repetition, the numbers will be with Cleveland. Each day's business must be numbered separately, commencing with No. 1. This rule applies also to Sunday business. Blank record sheets are provided to keep a record of message numbers, upon which both sent and received numbers are checked off.

Duplication of messages.—This is occasioned largely by want of care in checking received numbers, and also by delaying or neglecting the endorsements required on messages when sent. This should be avoided with all possible care. The evidence of a message having been sent should be placed thereon the instant transmission is complete.

Proper route and mode of counting words.—In order to prevent delay in the transmission of messages, arising from differences of opinion as to their proper route, or mode of counting, the sending office decides both as to route and as to what constitute single words in a message, and no office shall refuse to

receive and forward or deliver any message from any other office; but this rule must not be interpreted to permit errors to pass without correction.

Repeated messages.—To guard against mistakes or delays, the sender of a message may order it REPEATED; that is, telegraphed back to the originating office for comparison. For this, one-half the regular rate is charged in addition. The words "repetition," "paid," must be inserted immediately after the signature and charged for.

Insured messages.—Correctness in the transmission of messages can be INSURED by contract in writing, stating agreed amount of risk, and payment of premium thereon at the following rates, in addition to the usual charge for repeated messages, viz.: one per cent. for any distance not exceeding 1,000 miles, and two per cent. for any greater distance.

Care in transmission and receiving.—Extraordinary care must be exercised in sending and receiving any repeated and insured message. The receiving operator must copy the message carefully, and repeat it back over the same circuit before doing any other business. He should also personally transmit and have repeated to him the message over the next circuit, if any, or see that it is done. A memorandum of the time and circumstances attending the receiving, transmitting, and repeating back, should be written upon the original message, and the return copy must be compared and affixed to the original, a copy being always taken when repetition is made.

Whenever an insured or repeated message in course of transmission is stopped by an interruption of the line, the office from which it originated must be promptly notified.

Errors in sending.—When the sender discovers that he has made a letter wrong, he stops, makes several dots, and rewrites the word, and if a wrong word is sent, and he detects his mistake, he also stops, makes dots (msk) and commences again with the word sent correctly.

Punctuation in messages.—A period should close the address, and should also be used at the end of every complete sentence, except the one immediately preceding the signature. It is never used after initials, and no mark of punctuation should be used anywhere, except at the close of the address and in the body of the message.

Retaining the circuit.—In transmission, if an operator finds it necessary to wait a short time, and desires to retain the circuit, he can do so by opening the key, but should repeat "i" "i" every few seconds. If necessary to wait longer than one minute, he should close the key. If another operator then takes the circuit for business, he must wait until the other has finished.

Recalling a message.—It sometimes occurs that after a message has been left for transmission, circumstances arise to make its recall desirable. This can *only* be done by the sender's personal application, and in case the message has not actually been transmitted. Great care must be taken to prevent fraud in recalling messages by parties other than the sender.

Night or "red" messages.—The word "red" must precede all night or red messages in transmitting them. Offices which do not keep open all night must endeavor to transmit all "reds" on hand to their destination, or to the nearest repeating offices, before closing, and repeating and press report offices should forward all red messages during the night to their places of destination, or as near thereto as practicable. This, however, must not be understood to prevent the transmission of red messages at any time, before night, when an idle wire or otherwise unoccupied time affords the opportunity. Messages necessarily left over for transmission the next morning should precede new business, and in transmitting them, full rate messages known as "blacks," should precede the "reds."

CABLE MESSAGES OR CABLEGRAMS.

Cable messages.—All messages offered for transmission by cable should be written on cable blanks, subject to the conditions thereon, and to provide against mistakes, should be repeated back to the operator sending.

In cases where offices are not supplied with "cable blanks" the message may be written on the ordinary telegraph blank, but in this case managers are required to call the attention of the customer, especially to the clause in the printed heading making the company the agent of the sender without liability, to forward any message over the lines of any other company when necessary to reach its destination, and must require the customer's assent thereto.

Basis for counting words.—The maximum length of a chargeable word is fixed at *ten letters.* This applies also to the words in the address, destination, and signature. Should a word contain more than ten letters, every ten or fraction of ten letters is counted as a word. Words joined by a hyphen or separated by an apostrophe, are counted as so many separate words. The name and address of the receiver must consist of at least two words, and be paid for by the sender, and no message will be accepted which does not contain one text or body word.

Registered Addresses.—There are, says the New York Sun, one hundred and sixty thousand registered addresses kept by the Anglo-American, Direct United States, American Telegraph, and French Cable companies. These addresses comprise the names of the principal business firms sending and receiving cable dispatches in this country. To each of these registered addresses is appended one word, which represents it in all cable messages. This one word is always telegraphed instead of the address. The object of this registration is to save the expense of telegraphing, and also secure the utmost certainty of prompt delivery.

Charges.—Cable messages are charged according to a tariff

per word (the present charges being fifty cents per word). No charge is made for the transmission of the name of the place from, nor for the indication of any particular route, such as "via Falmouth," etc., etc. The reply to a cable message can be prepaid, the sender determining its length, which must not exceed thirty words ; the indication "reply prepaid," or "Rp," indicating the prepayment of a reply of ten words, must be inserted after the receiver's address, and paid for. When a reply of more or less than ten words is prepaid, the number of words must be specified and charged for. Should the reply contain more words than the number specified, the sender of the reply, on presenting it for transmission, must pay for the excess. If the original message cannot be delivered, or if the receiver formally refuses to send a reply, the terminal station will inform the sender of it by a telegram which takes the place of a reply. By inserting the words "acknowledgment paid," or "Cr," immediately after the address, before the text or body, and paying for the same, "Cr" counting as one word, the sender of a message will be notified by telegraph of the time of delivery.

Code or cipher "cable messages."—"Much money is saved in telegraphing, not only by cable, but by land lines, in the use of codes. All the leading branches of business have these codes, by means of which long messages may be sent by the use of few words. There is no extra charge for sending code messages by cable, as the words are always those that may be found in the dictionary. But there are many cipher dispatches sent composed of letters or figures. These are charged extra by counting three letters or figures to each word," or fraction of three as one word. Every separate figure, letter, initial, underline, and every group of two figures or letters, must be counted and charged for as one word. The European continental authorities, however, reserve to themselves the right to refuse messages containing secret or cipher letters.

Cable business, and time of transmission.—"New York city

sends and receives about two-thirds of all the cable business of the United States. Philadelphia comes next, then Chicago; while some of the smaller Southern cities, with their messages relating to cotton sales, outrank more northern cities like Boston, Baltimore, St. Louis, or Cincinnati." The average time occupied in the transmission of cablegrams, depends upon the traffic on the line when the message is handed in. Messages to London forwarded between 10 A. M. and 3 P. M., would reach destination sooner than one handed in at 7 P. M., as then the greater part of the European traffic is being transmitted."

SECTION XLII.

RECEIVING AND DELIVERY OF MESSAGES.

The reception of a message.—The reception must be as in the transmission, adding thereto the initial of both the sending and receiving operators, endorsing the time of receipt, and acknowledgment by giving the signal "OK," and the initial of the operator and office signal. Operators are particularly cautioned against acknowledging messages when in the least doubt of their correctness.

When the receiver finds he is not getting a message correctly, he breaks and repeats the last word received. If he wishes it repeated entirely, he says "R. R." (repeat).

Comparing checks.—After receiving a message, and before the "OK" is given, the operator should be careful to see that he has the right number of words, as called for by the check. He holds the circuit while doing this, by keeping his key open, but should not delay the business of the line by keeping it open longer than necessary. If they do not agree, he should compare with sender till error is found. This is usually done by commencing at period, and repeating the first letter in each word till the missing portion is discovered.

No message should pass through the hands of the receiving operator until he has counted the words and compared them with the check, and otherwise satisfied himself that it is correct, except in case a message is erroneously received from some distant point, where its correction would cause a serious delay. Under such circumstances, the manager causes the message to be delivered to the party addressed, with a notation thereon, stating that the message is thus delivered, subject to correction afterwards. When a message is thus delivered, the utmost dispatch must be used in securing correction.

Not copied.—The "Fr," "To" and "Sig." preceding the date, address, and signature in a message, are never copied by the receiver.

Messages improperly sent.—If any message is improperly sent, or the mode of counting is erroneous, the manager of the receiving office should immediately notify his superintendent; but this notification should not interfere with the prompt delivery of the message.

Abbreviating words.—In transmitting or receiving messages, operators are strictly forbidden to abbreviate words written in full by the sender, or drop any part of an address.

Repetition of a message on account of supposed error.—Should the receiver of any ordinary message require it to be repeated on account of supposed error, the application for repetition must be addressed to the sending station. Such application and repetition must be treated as two distinct messages, and be prepaid. Should the supposed error be found to have been the fault of the telegraph service, the charges for the application and repetition will be refunded, and the person found to be at fault will be required to repay the amount so refunded.

The use of capital letters.—In receiving messages the proper use of capitals "in the copy" should be strictly observed.

Whenever a message is to be dropped in the post-office, or sent by

train to its place of destination.—As the law requires in both cases a postage stamp to be affixed, the receiver will collect for postage and add it to the check. Such messages must contain instructions from the sender as to the places from which they are to be posted, and the instructions must be inserted immediately after the address and charged for as part of the message. The office receiving the same for delivery will affix the required postage stamp, deposit in the post-office, or deliver to train as may be directed, and check the amount of postage against the transmitting office as "for other lines."

Message delivered to another address.—Whenever the sender of a message which has failed of delivery, through insufficient or incorrect address, desires to have a copy delivered to another address; another message must be written, transmitted, and paid for, in all respects as a new message.

Messengers.—Messages are delivered by messengers, who should, in all cases, be able to read and write, and be appointed upon recommendation, from respectable sources, as to good character and clean and correct personal habits.

Messengers are required to be promptly on hand during all the hours of service, appointed for them, when not actually engaged in delivering messages, and their home address must be known to the manager in case of any special service which may be required of them.

Compensation.—Compensation of messengers is usually fixed at a certain rate per message, but where this cannot be properly done, they receive a fixed salary per week or month, and in addition, paid a fixed price per message for answers, the amount of which is designated by the district superintendent.

Opening messages.—No messenger is allowed to open, for any purpose, any message handed to him for delivery, or to allow any person to whom the same is not deliverable, to open the same, or to allow any one to know to whom he is conveying

any message, or to answer any question respecting the same conveying any information whatever.

Delivery on the proper blank, etc.—Messages for delivery should in all cases be written on the blank form of the company, provided for the purpose, in ink, on which the name of the office delivering the same, the date, the time of reception and the initials of the sending and receiving operators must appear. Every message delivered must also bear the check showing the number of words composing the message, whether paid, or collect, and the amount of tolls, if any, due thereon, and enclosed in the envelope of the company and sealed. If any tolls are to be collected, the amount must be written in words upon the envelope.

Copy retained.—A copy of all delivered messages must be retained in the office.

Delivery.—Messages are delivered without charge within the established free delivery limits of the terminal office—for delivery at a greater distance, a special charge is made to cover the cost of such delivery, and after entry in the messenger's book, must be delivered promptly to the person or firm addressed, at the place of delivery named thereon. If the person or persons addressed are absent, the message may be delivered to any agent, clerk, or member of the family who may be at the place of delivery to which the message is directed, who may be able to give receipt therefor. A receipt acknowledging delivery, showing the actual time received, and the name of the person giving receipt must, in all cases, be entered on the receipt blank of the messenger.

Delivery register book.—Principal offices keep a delivery register book, containing a record of every message received for delivery; the time received and sent out; the number, the person addressed, the name of the messenger, and the fact whether an answer is required or not. At smaller offices notations of

these facts are made upon the copy of the message retained in the office.

Messages marked "collect."—Every office which receives a message for transmission is required by the rules to see that it is paid for or payment properly guaranteed; therefore it becomes the duty of a manager, in case there is any doubt about being able to make the collection, to require the deposit of a sum sufficient to guarantee the company or himself against loss. If the party to whom the message is addressed refuses to pay for it, *the message should be delivered* whether it is paid for or not, and the office from which it was originally sent must be promptly notified *by telegraph*, stating the reason therefor, and a copy of the message made and sent *by mail* to the manager of the office, with the *reason* for being uncollectible endorsed thereon. The office returning a message WILL IN NO CASE request that it be NOT CHECKED; but the message must be entered upon the books, both at starting point and destination, precisely the same as if collection had been made—credit for the amount at the receiving office being taken in account current in monthly report, with which the message, or a copy, with reason for being uncollectible, should be returned as a voucher. *A copy of the office message notifying the sending office of failure to collect, must also be sent with the monthly report.* The office receiving the notice must, if possible, collect the amount from the sender of the message; in which case the amount collected should be entered in account current, as received from "guaranteed messages," and the copy of the message enclosed therewith. In case collection *cannot be made* of the sender, the message, endorsed with the reason, should also be enclosed with the monthly report but no account otherwise will be made of it. Uncollectible press reports should be treated in the same manner, except that a copy of the report need not be forwarded to the manager of the office at which it originated. When three or more messages are returned from any

office as uncollectible, and three or more messages are accounted for as "guaranteed," separate lists of each must be made, showing the amounts for "this" and "other lines," and the messages as sub-vouchers attached thereto.

Cases where delivery cannot be made.—Messages are not allowed to be delivered to janitors or porters of buildings, unless specially requested, or to be slipped under doors, or left where persons are not present to receive or receipt therefor.

In case a message is received after the place of business of the person to whom it is addressed is closed, and delivery cannot, therefore, be made, the messenger must leave a notice, placed in an envelope, and properly addressed, stating that a message has been received bearing the address written thereon, which awaits delivery at the office. This notice, blanks for which are provided by the company, and with which messengers should at all times be supplied, may be dropped into any letter box which may be provided for such purposes, or slipped under the door. The undelivered message must be promptly returned to the manager of the office, with reason for returning the same written thereon, and be sent out for delivery at the earliest moment practicable.

Delivery of important messages.—In the case of a message which cannot be delivered because the place of business to which it is directed is closed, the contents of which, nevertheless, indicate the importance of a speedy delivery, the message must be delivered at the party's residence, if known, or if it can be ascertained, or delivered elsewhere; but in no case, except at the place of original address, *to any other than the person addressed*, whose receipt therefor must be obtained. If delivery is not thus made, the message should be delivered to its original address at the earliest hour practicable.

Delivery of the same message to different persons.—When two or more copies of the same message are delivered to different persons, each one must be paid for.

Office message for better address.—In case an operator cannot find the person a message is directed to, they should send an office message back to the office where the message started from, giving the reason of non-delivery of message and asking for better address.

Delivery blanks.—The printed blanks used for delivery of messages are not allowed under any circumstances to be given out only for the purpose for which they are designed.

Delays in reply to messages.—In almost all cases delays in reply to messages, so frequent and annoying, and often supposed to be the fault of the telegraph, is almost invariably caused by the recipient of a message neglecting to answer it promptly.

Manners toward the public.—Learn to treat people as if you appreciated, and was willing to acknowledge their custom under *all circumstances;* be courteous and obliging: in short, act as any good business man would toward his customers.

SECTION XLIII.

TELEGRAPHIC BOOK-KEEPING AND MONTHLY REPORTS.

Accounts.—The method of keeping accounts is as simple as that of any ordinary business house. Each morning all messages of the previous day are carefully sorted, and those for each office registered by themselves in alphabetical order in a day-book or journal arranged for the purpose, ruled with columns to show how much is to be credited to them, and for other lines, or charged to other offices, and each column and the amount for each office footed by itself. Sunday business is entered with that of Saturday, except when Sunday commences the month, in which case it is entered with that of Monday.

Columns of entry.—All messages *sent paid*, or *received collect*, must be entered in the column of "*receipts*," and all messages

payable at other offices entered in column of "*checks.*" The column "other lines" in checks, is for amounts paid other lines for special delivery, and postage on delivered messages. The daily totals of each office may be entered in the order of consecutive dates on the "record sheets" or journal, in columns arranged for the purpose, keeping the business of each office by itself for the whole month. The daily totals can then be carried forward until the last day of the month, when the monthly totals can be transferred to check report.

Check ledger.—From the journal the amounts are posted in a "check ledger" to the debit or credit of the different offices, and finally from this posted in the general ledger, from which the balance sheets are made out, and monthly reports, accompanied by vouchers for all authorized expenditures, sent to the superintendent to be forwarded to New York, where they are expected to correspond with reports from other main offices.

Copy retained.—A copy of the report as rendered must be retained in the office.

The blanks needed for the composition of the ordinary regular monthly report.—

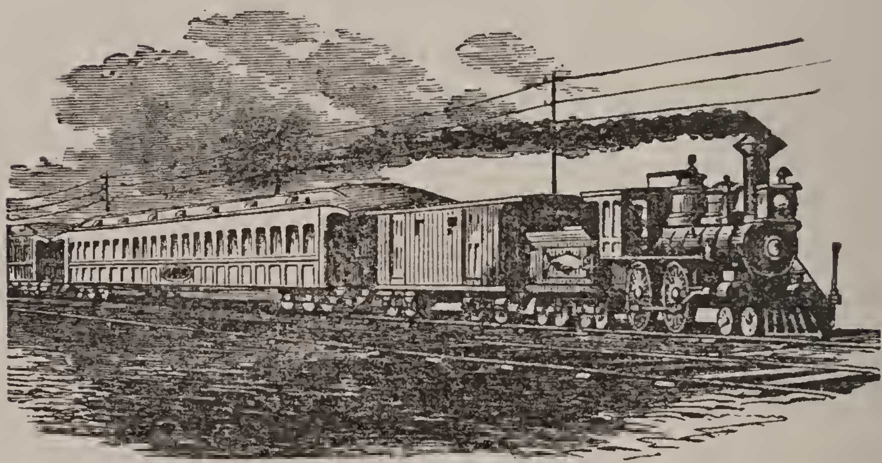
Monthly report, or account current.
Check report.
Free message report.
Half-rate message report.
Guaranteed message report.
Uncollected message report.
Cable report.
Blank vouchers.

On all these blanks full instructions are given, and their observance is rigorously required.

Promptness in forwarding reports and remittances is required of all managers, and no person is retained in charge of an office who is remiss in this respect.

PART FIFTH.

RAILWAY TELEGRAPHY.



The first railroad of which we have any mention, was constructed by Mr. Beaumont at the collieries near Newcastle-upon-Tyne, England, in 1672. Wooden rails were used, and the cars were drawn by horses. Iron rails were first used in Whitehaven, England, in 1738.

The controversy in regard to the first steam railroad train operated in this country is as yet unsettled, but the preponderance of the evidence would seem to show that it was the train run over the Albany & Schenectady road in 1831. The charter for this road was granted in 1826 to the Mohawk & Hudson River railroad company, and work upon it was begun in 1830.

It was completed in 1831, and in September of that year the first passenger train, which is also claimed to be the first steam passenger train ever run in this country, was sent over the rails from Albany to Schenectady and back. The year 1830 is generally accepted as the time from which to date the history of railroad enterprises. It took at least five years after the first road was built to get a notable increase of mileage, but to-day there are over 120,000 miles of railroad in the United States, and over 250,000 miles throughout the world. Among the large railway systems of this country are the following: Pennsylvania, controlling about 6,500 miles of road; Wabash, 3,425 miles; Chicago, Milwaukee & St. Paul, 4,500; Chicago & Northwestern, 3,500; Chicago, Burlington & Quincy, 4,068; Union Pacific; 3,873; Missouri Pacific, Iron Mountain, and other roads of the "Southern System," 5,775 miles; Louisville & Nashville, 2,500; Grand Trunk of Canada, 3,300; Central Pacific, 3,100; the Vanderbilt system of roads; the Seney system; the Baltimore & Ohio, and the Erie. If we could judge anything of the prospects of electric railways, by comparison of their history with that of the now well-established steam railroads, their success would be very well assured. It is only about two years since Edison's experimental electric railway was built at Menlo Park, about the same time that Siemens was experimenting with a similar line in Berlin, and the first electric railway commercially used was built by Siemens, near the same city, only about one year ago, and yet there are now about one hundred miles of such roads in working order, authorized or in course of construction. There are short roads in use in Germany, Holland and Ireland, and roads are projected or in course of construction in Austria, England, Italy, the United States and Wales.

SECTION XLIV.

MANAGEMENT OF RAILWAY OFFICES, TRAIN DISPATCHERS' AND OPERATORS' DUTIES — CIRCUIT REGULATIONS — COMMERCIAL BUSINESS—CAR REPORTS OR STATEMENTS—TIME BY TELEGRAPH.

Since the perfection of the telegraph and its application to the systems of daily life and business, railway trains are almost universally run by it, although its use is supplemented by time tables and usually the most elaborate system of rules and regulations that can be devised, the peculiarities and experiences of each road causing some little variations to suit circumstances and surroundings, while generally the methods and practices do not differ widely.

"The increase of traffic, with the vast number of trains to be run over the different lines, demonstrated at an early day the difficulty in arranging rules and time schedules equal to all emergencies, for governing the running of these trains—rules that could be practically enforced and that would produce prompt and safe movement of trains in both directions over a single track at all times, and repeated failures to produce such results have undoubtedly, in many instances, resulted in the construction of a second track when it was not necessary and could not be afforded."

The information regarding railway telegraphy, has been derived from official sources in connection with the most prominent railways in this country, and has been carefully compiled and prepared, with the aim of making it as complete and comprehensive as the greatest brevity consistent with the object aimed at will permit; therefore, it is believed that the information is more complete than anything hitherto published in a work of this kind.

Railway telegraphy, its advantages.—On a single track it possesses the advantage over the old style of working by schedule only, of economy, simplicity, the more speedy movement of trains, preventing blockades, and the unnecessary detention of superior trains waiting for inferior ones.

Train dispatching.—The system known as the American system of train dispatching, as practiced on nearly every road in the United States and Canada, has for its aim the moving of opposing trains along a single track line, and to fix their meeting points. On more than one track the business of train dispatching is usually little more than to keep slow trains out of the way of faster ones, except in cases of emergencies.

Although the principles are common, yet each road has a system of its own, differing from the others in detail, in the schedule rights given to trains, in the manner of giving and receiving the train orders, and in the manner of checks to avoid the occurrence of errors.

Origin of the system.—The present system of train dispatching originated in a system first adopted by the Erie Railway, introduced in 1850 by Mr. Charles Minott, general superintendent, who first run a train over that road by telegraph, although it is claimed that other railway men previous to that date had availed themselves of the use of the telegraph in the movement of trains.

"During the past ten years the care and attention given the subject by prominent and experienced men, has greatly improved and strengthened the older systems; also experience has demonstrated the weak points, and where to place the strongest guards against danger."

But there is as yet among practical railroad men, a wide diversity of opinion in the form and interpretation of train rules and orders, resulting in different constructions being placed upon similarly worded rules. Successful train dispatching, however,

means simple, well worded orders, made so explicit and plain as to be beyond the possibility of misconstruction.

Management.—All employes in the telegraph department of railways are under the management and control of the telegraph superintendent, subject to the general instructions of division superintendents; and operators are under the immediate charge of the chief train dispatchers of the division on which they may be employed.

The train dispatcher.—The position of train dispatcher is second in importance to no position on the road. He is frequently an expert operator, but it is not absolutely necessary that he should be a telegrapher, although to have an intelligent understanding of what is going on, he should be able to read all that passes on the wire. He should be a man of more than average ability, of good judgment, clear head, and strictly temperate. "Quick dispatch" is what shippers of perishable and export freight, in these days, demand of railroads, and without an efficient, clear-headed train dispatcher, this important freight cannot show a good record, as trains are liable to set on sidings, waiting for an expected train which may be delayed several hours, causing a stoppage of all the trains on the road. Train dispatchers must have a thorough knowledge of the road, length of trains, siding and grades, and must know how far each conductor, engineer, and operator may be depended upon, and in fact the minute parts of everything connected with his department; and last but not least, his time tables. He is authority so far as it goes, on all subjects pertaining to the time table and rights of trains, regardless of opinions.

Authority.—Division superintendents, and train dispatchers under their directions, are the *only persons authorized* to give special orders, and the authority is limited to their respective districts or divisions; thus, in issuing special orders, the train dispatcher represents the superintendent. He has absolute

control over all trains, and his orders must be obeyed, except when palpably they would cause danger.

Not more than *one person* on a district or division is permitted at the same time to give special orders for the movement of trains.

Division superintendent.—On the majority of roads the train dispatcher is required to give special orders in the name of the division superintendent, adding thereto the initials of his own name.

Dispatchers' duties.—In a central office on the line of a railway, the train dispatcher, with the necessary assistants in corresponding positions to make the service complete, receives telegraphic reports and records the movements of all trains in his division in and out of stations. It is his duty to keep the locality of every train running on the division constantly in his mind. The trains are run by the schedule or train rules, or when any train is "off time," and has lost all rights, or what is called "wild," *i. e.*, having no rights at all, then the dispatcher takes such trains in hand and orders them to move as he sees fit to hasten their progress, consistent with safety. He is also intrusted with the ordinary working of the lines, testing and changing circuits, the direction of operators and repairers in the discharge of their respective duties, and as a rule must report each morning to the superintendent of telegraph the state of the weather along the line, the condition of the circuits upon his respective division, and the nature of any interruptions that have existed or do exist, and what measures have been taken for repairs.

Construction of orders.—Train dispatchers must themselves write all messages involving the movement of trains, and must not permit another person to do it for them, and before sending any special orders they are required to write them out in full in their train order book.

On some roads the dispatcher sends the order from memory, and copies it in his order book when the receiving operator repeats it, who is required to repeat the order precisely as received.

Responsibility.—Where the roads have only single tracks, the labors and responsibility of a train dispatcher are very great. Very few realize the weight of the responsibility resting on the mind of the train dispatcher, not only must he keep a watch over one train which is speeding along at a rate of 35 or 40 miles an hour, bearing its precious freight of human lives, but he must follow the complicated movements of many other trains with their thousands of lives and valuable property, which a blunder or an inaccuracy of his would hurl to death and ruin. On many roads numerous trains traveling in opposite directions are on a division at one time. All these have to meet and pass each other somewhere along the division. The dispatcher must know just where to hold the train, where to send that one from and how far to run it, and know within a second just when to expect a train at a station. With his time-table before him, containing the names of all stations and numbers of all trains, the dispatcher sits close to the operator, surrounded by clicking machines, checks off train and station as arrivals are rapidly telegraphed, and quickly issues his orders to the operator, to be sent to expectant trainmen all along the division.

For any accident by collision on a road, the dispatcher is held responsible, unless it is shown that his orders were disobeyed. The butting collision is peculiarly an accident of management. A sudden storm, a land slide, many other things which cannot well be foreseen, may cause derailments; a break-down, a fog or some such cause may explain a rear collision, but a butting collision in its nature presupposes carelessness or a mistake somewhere, and the blame is generally supposed to rest between the train dispatcher, operator, and the two men upon whom devolves the movement of the train itself, the conductor and the engineer.

Cause of accidents.—The improved construction of rolling stock has reduced almost to a minimum the number of accidents caused by defective running gear; the fruitful misplaced switch is giving way to automatic devices that are secure; and the adoption of the combined interlocking switches implies as complete guarantee of safety as human ingenuity can probably contrive. The use of such improvements in the mechanical science of railroading has had the effect of slowly, but surely, transferring the responsibility for all accidents, from causes that were often not determinable at all, directly and unmistakably to individual negligence or criminal inefficiency. "Undoubtedly due to one of two causes: either the capacity of the employe has been over-taxed to such an extent by long hours of work, that his faculties can no longer be relied upon; or his intelligence and general worth as an employe are of so low a grade that he maliciously neglects or fails to comprehend his duties." Speaking on this subject, the *New York Herald* says that the trouble with our great railroad systems is that but one consideration is thought of—namely, the necessity of large dividends, and the tendency to manage the roads with criminal economy, and that in many instances the true underlying cause of disasters may be attributed to this cause.

It is undoubtedly true that the standard of the service may be much improved, to the benefit of both the public and the companies, by the payment of better salaries, and thus always securing and retaining the services of good men. The careless act of a single worthless employe may in a moment destroy property of a value sufficiently large to handsomely increase the salary of every employe in the service of the company for a considerable length of time.

Caution regarding accidents.—Dispatchers are ever to bear in mind the vital necessity of exercising the greatest possible caution at all times in giving orders to run trains in any manner by telegraph, and although required to be prompt and diligent to

give trains such dispatch as is consistent with safety, they are to remember at all times that *safety is more important* than dispatch, and in cases of doubt to *always take the safe side. Safety is the first consideration*, and all other matters must be made secondary.

Length of divisions and number of hours' labor.—The length of division and the hours allotted to each train dispatcher vary considerably; no general rule can be made applicable, as such matters must be governed entirely by the quantity of work. While on some roads a dispatcher can work twelve hours on a stretch, on others it is found the labor is so severe that six hours' continuous work is the limit. On most of railways the weight of his responsibility is heavy, the hours of labor long and tiresome, and the rate of compensation light considering the responsibilities.

Relief of dispatchers.—When the control of a division is transferred by one dispatcher to another, the greatest care must be used by both dispatchers to have the position of all trains understood as well as all special orders, which have been issued, which are yet to be carried out. The train dispatcher and the telegraph operator in his office must not be relieved at the same hours.

The "line" operator.—It is absolutely important that he be impressed with the sense of responsibility resting upon him. "His apprenticeship and training should be such as to assure this as far as possible, and before appointment every operator should be subjected to a careful examination, above all upon his knowledge of the company's rules and methods in regard to the handling of train orders and signals; then as to his skill in sending and receiving messages, and finally as to his ability to perform such manipulations of the wires as are occasionally required of way offices when interruptions occur on the line. A line operator may do much to keep business moving by advising the dispatcher of arrivals, delays, and other things occurring near him, which have a bearing on train movements, but which

the letter of his instructions may not require him to report. One who does this intelligently prepares and recommends himself for promotion."

Operator's duties.—They are required to devote themselves exclusively to the service of the company during business hours; those having other duties to perform in the transportation or freight department are not permitted to allow such duties to prevent the proper attention to the telegraph, which service must be regarded as the first in importance.

Office manager.—At offices where there is but one day and one night operator, the day operator acts as manager, and is held responsible for the commercial and other business done at his office.

Office hours.—At stations where there is no night operator, the hours are from 7 A. M. until relieved by the train dispatcher. Office hours, where both day and night operators are employed: day operator from 7 A. M. to 7 P. M.; night operator from 7 P. M. to 7 A. M. Both operators are required to come on duty promptly at the regular hour, and remain on duty until relieved or excused by the train dispatcher. Office hours are varied by train dispatchers as cases of emergency may require; where there are more than one day or night operator employed, there must be one person on duty at all hours, especially before the arrival of an expected train.

Meals.—Ordinarily all operators are allowed one hour for each meal, but where two or more day or night operators are employed, they must not all be absent at their meals at the same time.

Office hours, Sundays.—On Sunday, the hours are arranged upon each division of a road as the service may require.

Duty required of operators in case of accident.—In case of accident no account or message respecting it other than regular tariff business is permitted to be sent, unless to an officer of the

railway company, signed by an agent, conductor, or other authorized person, nor is it allowed to be made the subject of conversation or remark ; particulars for the public or for publication is furnished by officers of the company only.

Extra duty required of night operators.—In addition to their regular duties night operators are on many lines required to report "weather signals," or on some lines the signal "6" to the train dispatcher's office each hour from 9 P. M. until relieved by the day operator, and on some lines other extra duties are required, such as selling tickets for night passenger trains, checking baggage, etc.

No admittance in offices.—As a rule no person is allowed in the telegraph offices of a railway, whose duty does not require him to be there. The safety of trains and privacy of dispatches intrusted to the telegraph requires that this rule shall be obeyed.

Subject to supervision of station agents.—Operators at stations are subject to the supervision of the station agent, who is required to see that they properly attend to their duties.

Operator required to be in office.—When trains are due or at their station, the operator is required to be in his office, and not on the platform, unless the service requires his presence there.

Train register.—Operators are required to keep a register of all trains passing their office, and the reports from such other offices as the train dispatcher may require, and must keep the time of trains properly indicated upon the *bulletin boards* at the offices where they are used.

Change of residence.—Operators are required to change their places of residence at the discretion of the superintendent of telegraph; and at stations where a day operator only is employed, he must inform the night watchman or nearest track foreman, where he may be found during the night, should he be required.

Strictly prohibited.—The use of instruments or batteries in

offices either in addition to or in place of those furnished for their regular equipment; and the stringing of private wires in or about the station, or from a station to another point in the neighborhood is *strictly prohibited* on most roads; and operators are not permitted to make any changes of wires, nor to move instruments without orders, as all such changes and removals should be made by the division repairer.

Students.—They are not allowed to practice in any office on a railway without permission from the superintendent of telegraph. Dispatchers and operators as a general thing on most roads are kept very busy, and have no time for giving instructions.

Circuit regulations.—On some railway lines such circuit regulations are adopted as gives equal right to all, thus avoiding contention of circuit, and saving much valuable time usually consumed in calling.

Circuit signals.—On all lines certain circuit controlling signals are made use of, usually consisting of numerals, which commands immediate suspension of all subordinate business, and vary greatly in their meaning on different lines.

Testing wire signals.—Usually on all lines the signal word "*wire*" or "*line*" is used by chief operators to test for trouble and settle disputes; operators can also use it to report trouble on the wires. The signal has no absolute rights, but a good reason is demanded for any failure to give way to it. Officers of the company are requested to respect it, as a moment or two is usually sufficient to render wires available, that would otherwise be useless for a long time.

Value of signals.—Signals must be immediately respected according to their meaning. When a wire is used for both railway and commercial business, the signals "*stocks*" and "*wire*" has preference over ordinary business; however, certain signals of the railway company have preference over these, and in case

all the wires are useless, except one, then the rules in force upon the railway wire govern that wire until the others are repaired.

Commercial business.—The commercial business on most of railway lines is controlled by the *Western Union Telegraph Com pany* under an agreement between the railway company and the latter, the operators acting as agents for the telegraph company, and making monthly reports and remittances to that company. All messages except such as pertain to the business of the railway company, and ordinary communications of its officers and agents, are considered as business of the telegraph company, and must be done subject to the rules and regulations of that company, so far as such rules do not conflict with those of the railway company.

Western Union city office.—At points where a city office is maintained by the telegraph company, the railway operator need only transact such business for passengers and others who are unable to go to the commercial office, and must account for the same to the manager of the city office as often as required.

Commissions.—At all railway offices where commercial business is done, the manager is usually allowed *ten per cent. of the gross receipts* of the office each month, in consideration that he will give the commercial business transacted at or through his office prompt and careful attention.

Railway messages.—Railway business is transacted with much less formality than is used in commercial messages. The names in addresses and signatures are sometimes abbreviated to the initials simply. Dates are often omitted, and no checks are sent; also, many words in the body of messages are abbreviated. When, however, the business of a railway company passes off from its own line, it is treated the same as other free or paid business.

Train reports.—On the majority of railways, operators are required to keep a record of all trains which pass their stations,

as well as reports of trains from other offices. The form for train reports varies on different lines. The common form is to call the train dispatcher's office, and make the signal "OS" several times, and sign the office call; then give the number of the train and its direction, saying on time abbreviated to "OT," or, if late, stating (in figures) the exact time of its arrival (Ar), and departure (D), and always signing the office call at the close. The *correct time* is required to be reported, taken from the office clock and not from trainmen. Offices failing to hear train reports, must obtain them from the dispatcher's office. If an operator should be unable to know from any cause whether trains have passed, he should at once acknowledge the fact, when called upon for a report. An excuse might be received for an acknowledged neglect, but no excuse is received for sleeping on duty, and reporting trains incorrectly on that account. When trains are delayed beyond their schedule time, the operator should always ascertain the cause, and report the details to the division superintendent's office.

Car reports or statements.—In order that the most may be made of the equipment of a road, rigid system is necessary, that the condition and exact whereabouts of that equipment may be always apparent at headquarters, and that it may be handled with the minimum of confusion and useless or unnecessary movement. Hence on all well regulated roads, agents are required to make out daily a detailed "car report" to be transmitted by telegraph to the division superintendent's office, the form of which is about the same on all roads, "and relate entirely to the condition of each station relative to freight car equipment. Thus each station indicates, under the head of 'long box,' 'medium box,' 'short box,' 'flat,' 'stock,' 'coal,' (sideboard, flat or dump), and 'foreign,' it has 'on hand loaded for this station,' 'on hand empty,' it has 'to spare,' or that it wants for service from that station. If there are absolutely no cars under any circumstances at the station, the report

is simply 'no cars.' Agents at junctions, or at stations passed by freight trains for more than one line or branch of the road, designate the number of loaded cars for each line or branch. The system of telegraphy thus so rapidly and succinctly performing a specific service may be greatly shortened by the use of single letters to express whole sentences. Thus 'A' may mean 'long box cars on hand loaded for this station,' a figure accompanying indicating the number of that particular kind; or 'J' may refer to 'to cars on hand loaded for this station,' as the figure designating before, and so on."

Time of sending car reports.—The time varies on different roads, but is usually sent in the morning on most of roads (all business on the line being for the time suspended as far as practicable). The most distant station commences, and as one station finishes another begins, and so on in turn until all have reported. Small stations, having no telegraph apparatus of their own, send their reports or returns to the nearest station having such apparatus, using the first passing train for the purpose.

Method of sending time.—On all roads an accurate system of maintaining a standard of time is a necessity, in order to assure safety in running trains and avoid confusion. The method of sending time differs but little on the different railways, and is usually sent at 12 o'clock noon, although some roads prefer the morning, and others the latter part of the afternoon, either of the above being preferred on account of its not taking up valuable time at the more busy hours of the day; for the purpose of sending time, all other business is suspended a few moments be fore the hour selected. In order to give every operator an opportunity to adjust his instrument and prepare to take time, commencing one, and on some roads two minutes before the hour selected, the operator who sends the time beats the seconds with his key, and at precisely the hour says "i i," or repeats

"S," and gives the hour selected, after which, business proceeds as usual.

The Pennsylvania Company's system of sending time.—This company have adapted and carried into successful operation a system of telegraphic time signals which is probably the most perfect system in use. A telegraph circuit is established between the clock of the Allegheny observatory, and the general offices of the company at Pittsburg. The clock of the observatory is regulated by astronomical observations, and the pendulum of the clock is so connected with the circuit that the latter is broken and closed at each vibration, and thus regular pulsations of seconds are transmitted over the wire, and sounded upon a bell in the telegraph rooms of the general offices, at any time during the day or night the bell may be switched in, and the standard clock corrected to within an infinitesimal part of a second. The arrangement of the mechanism at the observatory is such that the seconds are beat consecutively until the fiftieth inclusive; there is then a pause (open circuit) of ten seconds, after which the first beat indicates the commencement of the next minute, the beats being continued as before. The closing of the hour is indicated by the circuit remaining open the entire last sixtieth minute. The first beat thereafter marks the commencement of the next hour sharp. The pauses are considered as preliminary signals for comparison with clocks.

The hour of sending "time."—The time is transmitted over all the lines of the company at 4 P. M. of each day. At about 3:55 P. M. the operator at Pittsburgh signals time (business being suspended on the circuits for ten minutes to give way to time). The word time is repeated several times to call attention of the different offices on the circuits. At or about 3:57 he connects the main lines by automatic repeaters with the observatory circuit. After the circuit is complete, the second beats are repeated on the main circuit as heretofore described.

By this process exact Standard time is transmitted each day,

and clocks at different main offices of the road carefully regulated by observatory time. Employes are instructed to compare daily.

SECTION XLV.

CLASSIFICATION OF TRAINS—TECHNICAL TERMS.

Trains, how classified.—Trains are classified as regular, extra, and wild. The time table, as usually arranged, only indicating regular trains.

Regular trains.—The trains specifically enumerated on the time table and divided into two classes viz: passenger and freight.

First class.—Passenger trains are rated as first class trains, their importance as to superiority generally graded in the following order: express, mail, accommodation and way.

Second class.—Freights, the importance of their superiority rated as follows: stock, through, and local or way.

Speed and rights of trains.—The speed of each is regulated to suit the grades and conditions of the road. First class or trains of superior class have the absolute *right to the road* over those of inferior class, and the latter must be kept entirely out of their way.

Trains passing.—Where *trains are to pass each other*, the train having the *right to the road* occupies the *main track*, excepting when there are *special orders* to the contrary, or it shall be impracticable to thus pass.

Extra trains or engines.—Trains following trains of the first or second class under the prescribed signals, in which case they possess the same schedule rights as the train which carry the signals. On most of roads, however, each several train following a regular under signals is referred to as a "section" of the regu-

lar; while on others, all trains not stated on the time table are designated by the term "extra" or "wild."

Wild trains.—Trains classed as special, wild, or work trains, and run by special order, unless otherwise provided for. It is commonly supposed that special trains have the right of way over all others, but this is very rarely the case. On great occasions a special time table is prepared for the extra train, and then the others give way to it. If, however, at any time they shall fall behind in the time of their own special schedule, they at once pass into the hands of the train despatcher, the same as any other train.

Trains, how numbered.—Trains are numbered, beginning at number 1, 3, 5, or 2, 4, 6, and so on up; even numbers one way, odd numbers the other.

Time table or schedule.—The time table is designed for the better regulation of trains, giving the time of arrival and departure, and meeting points, of all regular trains, the *full faced figures* indicating the regular passing places; also, stating the class of train under each number, usually passenger trains first.

Rules are also added to the time table directing how the trains are to proceed with relation to each other, and partake very generally of the character of the men introducing them, hence the lack of a desirable system and uniformity between the different roads in rules governing the movement of trains.

The time table also shows the distance between each station and the distance from the terminal station to any other station on the road, and usually gives the number of feet of siding at each station, and also designate at what stations day and night telegraph offices are located, the letter D indicating day, and N day and night offices.

"If it were possible to arrange time tables to show the number of trains actually required to be run each day, and to know that these trains would go on time, that no delays occur from

accident, extra service, the weather, or the hundreds of other obstacles to be met, then the telegraph order could be dispensed with; but under the circumstances as they exist it forms, and always will, an important and constant aid, and is in fact indispensable on all the longer single track lines."

Sections of trains.—Trains may consist of one or several sections, and are run under cover of prescribed signals, carried on front of the engine. When two or more trains are running on the same time, under cover of signals, the leading train is considered as the first section, the next as the second section, and so on indefinitely. When more than one section, the engine of each section except the last is required to carry the prescribed signals to indicate that another train is following.

Freights and lower grades of trains on siding.—They must be on siding and clear passenger trains, leaving time not less than five minutes, and on some roads ten minutes.

Right of road.—Trains going in one direction on a road, always have the right of way over those of the same class going in the opposite direction, the discrimination in the direction, being usually in favor of that current of travel that it is most important the railway company should favor.

Direction of trains on double track.—In England the universal rule is for trains to take the *left hand* track, and on some roads in this country the same rule is observed, but on most roads all trains in either direction, when running, are required to take the *right hand* track, unless stated otherwise in the time table, or by special order, in case of accident or obstruction.

Speed.—The *maximum* rate of speed on railways in this country, with a few exceptions, for passenger trains, is about 40 miles per hour, or one mile in one and a half minutes; the average speed is probably about 30 miles an hour. The average speed for freight trains is about five minutes to the mile, or from 12 to 15 miles an hour.

Fastest train.—Probably the fastest train in this country, and one which is little below the speed of the fastest English trains for the same distance, is the Philadelphia express on the Pennsylvania railroad, which makes the run of 88.4 miles from Jersey City to Philadelphia in 1 hour 52 minutes, including three stops, or at the rate of 47.8 miles per hour. In England the "Flying Dutchman" on the Great Western Railway runs from London to Swindon, 77¼ miles, in 1 hour 27 minutes, or 53.3 miles an hour. This train used to be the fastest in the world, but the speed is fully equaled by some of the Leeds expresses on the Great Northern, which run 70¼ miles in 1 hour 17 minutes without stoppage, or at the rate of 54.7 miles an hour. On both the American and English railroads for short stretches of straight track, with a good road bed and favoring grades, a speed of 60 miles an hour is not very uncommon.

Distance between trains.—Passenger trains (while running in the same direction) or sections of passenger trains, are required to keep at least ten minutes apart; on some roads passenger trains are required to keep *fifteen or twenty minutes* apart to insure safety. All other trains of whatever kind, running in the same direction, whether as sections of one train or otherwise, are required to run not less than five minutes apart, except in closing up at stations or passing places; however, trains following others must approach stations with proper care, so as to prevent the possibility of a *collision* with the forward trains, or injury to persons about the premises. The neglect of these precautions are always a source of danger. A very common cause of rear collisions seems to be the running of trains so close together that, in case of a mishap to the first train, or a sudden stop from any cause, there is no time to warn and stop the next one. This is especially true of freight trains running in sections, as they are run on most roads with heavy traffic.

"*Know-Nothing*" *stops.*—Stops made at grade crossings of other roads and at draw-bridges. The name originated in

Massachusetts, so called because the law requiring full stops to be made at such places was passed by the famous "Know-Nothing" legislature of 1855.

Main track.—The main track or tracks of a road upon which the trains are run.

Side track.—A track running parallel with the main track, and connected with it at each end by a switch. This track varies in length and is sometimes called a "siding," or "turn-out."

Spur track.—A short track connected only at one end with the main track running parallel with the latter or otherwise.

Y.—A track connecting two tracks in the general form of the letter Y.

Guage of track.—The distance between the rails. The national guage in this country is 4 feet 8½ inches, but 5 feet is still the prevailing guage on many of the Southern roads, and 4 feet 9 inches the standard guage of the Pennsylvania company, although there is virtually no difference between a 4 feet 9 inch and a 4 feet 8½ inch guage, the same cars running over each readily.

In England a depot is called a "railway station," a leeper or pusher is a "bank engine," frogs are known as "diamond crossings," and ties are called "sleepers." An engineer is an "engine driver," switching is the "marshaling of trains." A grade crossing is a "level crossing," a track foreman answers to the title of "gager or platelayer," rails are called "metals," baggage is "luggage," a car is a "carriage," and a flying switch is a "shunt."

SECTION XLVI.

RAILWAY SIGNALS—ELECTRIC SAFETY SIGNALS.

At the present time there exists a great diversity of meaning in the system of signals on the different roads, although it would seem for many reasons that a uniform system of train signals, applicable to all roads, is desirable. However, the unnecessary

and dangerous dissimilarity of railway signals in this country has become such a subject for grave consideration, that the Association of American Railroad Superintendents, at their recent meeting in New York, adopted and recommended a code of signals for use on all roads in the country. And the last annual report of the commissioner of railroads urges strongly that all railroads should use one uniform set of train signals, which shall have the same meaning on all railroads.

Signal devices.—There are different modes of signalling; some roads use hand-flags or lamps of the proper color by day or night, displayed in a fixed position, while most of the more important railways now employ either electric or automatic mechanical signal devices or target apparatus, arranged for displaying the proper signals by day and night, manipulated from within the telegraph office. However, where such devices are used, operators are also required to have a red flag and red hand lantern and torpedoes ready for immediate use in case of trouble with the regular signals, or during foggy or stormy weather. The regular signal lantern should be lighted one hour before sunset, and kept burning until one hour after sunrise.

Colors used.—The colors used are red, white, green, and blue; red generally for orders, although some roads use green.

Danger signals.—A red flag, or red displayed in the regular signal device by day, a red light by night, a lantern swung across the track, a torpedo exploded thereon, the absence of lights at switches and crossings, where usually shown, or any object violently waved on the track is a signal of danger, and means "stop."

White signal.—The display of a white signal or a white flag is the signal of safety, and when exhibited it indicates that all is right for the train to pass.

Red lights at switches indicate that the switches are set for sidings.

Green lights at switches indicate that switches are for the main tracks.

Blue signal.—A blue flag by day, and a blue light at night displayed on the road, is the signal for caution in passing over the track. A blue signal is also used by car inspectors.

Green and white.—Is a signal used to stop trains at signal stations where trains do not stop unless signaled.

The semaphore.—This apparatus is probably the best and most satisfactory signal contrivance in use, as it is possible to give a greater number of different signals with this device than with any other yet invented. It is usually placed where there are double tracks, or where roads cross each other, and consists of a pole, on which is mounted "as a target" one, two, or more arms, disks, or cross arms, as occasion may require, which may be painted "red" and "white," or any desired color. The signals are indicated by the position of the arms, which may be turned either in a perpendicular, horizontal, or any required position; at night their position is indicated by the proper colored lights. This device is used for train orders and to block the different sections of both passenger and freight trains or trains following each other.

The Gravit semaphore.—This apparatus, which has been in successful operation on the Lake Shore Railway for some time, is considered not only superior to any semaphore yet devised, but is as nearly perfect as an arrangement for the same purpose can be made. Its main feature is a right-angled fixture adjustable in six different and distinct positions, and moved by a lever placed within reach of the telegraph operator. When both arms of the triangle are up, the signal is that both tracks are blocked and all trains must stop. Both arms down, indicates that both tracks are clear, and trains may proceed in each direction. The

south track being blocked, an arm is pointed south, the other arm lying perpendicularly on the supporting post; north track blocked, *vice versa*. Also, both arms may be made to project in one direction or the other at the sides. At night, in addition to the adjustment of the arms, lights may be shown in the semaphore lantern to approaching trains, a red light signifying that the train must stop, a white light that it may proceed, etc. The operator, after receiving his telegraphed orders and making the proper movement of the arms, must reply that he has done so.—*Railroader.*

Train order signal, normal position of.—This signal, which is pre-eminently a danger signal, is displayed on many roads *only* when a train is to be stopped for orders; and on others the normal position of the signal indicates danger. However, in all systems of danger signals, it is now generally conceded that the *normal position* of the signal at all stations should be *at danger*, and the signal never *secured* or fastened in any other position except at offices where there is no night operator; "thus the signal is always in a position to stop trains unless moved to another position to show that there are no orders for them."

All trains must stop for danger signal, and must not proceed until it is removed, and conductor and engineer receive orders, or a clearance showing there are no orders for them.

Trains "blocked."—As a rule, on many roads all trains must be blocked ten minutes apart, except where freight trains are closing up to take siding, or where the schedule allows a less time. Any train following a passenger train on the main track, must be held by danger signal for ten minutes after the departure of the passenger train.

Train signals.—Each train, running after sunset, or when obscured by fog or other cause, must display the headlight in front and two red lights in the rear. On passenger trains the rear lights are placed side by side, about three feet apart. On freight

trains they are placed on the sides or top of the rear car; but on some roads two green flags by day and two green lights by night must be displayed, one on each side of the rear of the train as markers.

Signals on engines.—Two red flags unfurled by day, and two red lights by night, displayed in the places provided for that purpose *on the front of an engine*, indicate that the engine or train is to be *followed by another having the same schedule rights.* In case by accident two red flags or two red lights *cannot be obtained*, one red flag or one red light indicates the same thing. One section, following another under signals as above prescribed, must always be taken and considered to be a part of and have *all the rights* of the leading train, *and no more*, and the conductors of all other trains must so regard it—except when trains are directed to run by special order; in such cases a following train *will not possess* the rights of the leading train, unless specially authorized to do so. On some roads "green signals" are used for this purpose instead of "red," and on others the green signal indicates the train is a wild train. On some roads when white signals are displayed it indicates that the train is an "extra." A yellow flag or light carried is a signal to trackmen that the telegraph line is out of order and must be examined by them and repaired.

The "torpedo" danger signal.—An exploding cap or torpedo, clamped to the top of the rail, is an extra danger signal; to be used in addition to the regular signals at night, in foggy weather and in cases of accident or emergency, when other signals cannot be distinctly seen or relied upon. The explosion of one of these signals is a warning to stop the train immediately; the explosion of two of these signals is a warning to check the speed of the train immediately and look out for the regular danger signal. The torpedo alarm has proven immensely serviceable and is in use on all roads. Especially is its use valuable when an accident occurs to a train, or if by any other cause the road

is obstructed, the rear brakeman is *immediately* required to go back the *prescribed distance* with danger signals to stop any train or engine which may be following. *Extra trains and engines are at all times to be expected*, and therefore the most careful compliance with the precautions for safety is necessary. However, the "torpedo" sometimes fails in snowy weather, being brushed from the rail at those times by the snow and ice pushed ahead of the engine. *Fusee* signals are often used and seem to deserve a wider application, as they are said to be especially valuable in a driving snow storm, as they illuminate the whole track and the falling snowflakes. And the feature of having them burn only a stated length of time must commend itself at once as a valuable help in railroad service. If it were desired to make day fusee signals it could easily be done by burning some mixture compounded so as to produce a large volume of heavy smoke instead of a red light, as in night signals.

Uniform code of signals.—At a recent meeting in New York of the Association of American Railroad Superintendents, the following uniform code of signals was recommended for adoption on all the roads in the country:

ENGINEMEN'S SIGNAL BY WHISTLE.

1. *One* short blast of the whistle is a signal to apply the brakes—stop.

2. *Two* long blasts of the whistle is a signal to throw off the brakes.

3. *Two* short blasts of the whistle, when running, is an answer to signal of conductor to stop at next station.

4. *Three* blasts of the whistle, when standing, is a signal that the engine or train will back.

5. *Three* short blasts of the whistle, while running, is a signal to be given by passing trains when carrying signals for a following train, to call attention to the signals, and *four* short blasts is the answer to it.

6. *Four* long blasts of the whistle is a signal to call in the flagman or signalman.

7. *Six* short blasts of the whistle is the engineman's call for signals.

8. *Two* long, followed by two short blasts of the whistle, when running, is a signal for approaching a road-crossing at grade.

9. *One* long blast of the whistle is a signal for approaching stations, railroad-crossings and junctions.

10. A succession of short blasts of the whistle is an alarm for cattle, and may be used to call the attention of trainmen to danger.

11. A blast of the whistle of five seconds' duration will be considered as a long blast.

CONDUCTOR'S SIGNALS BY BELL CORD.

1. *One* tap of the gong, when the engine is standing, is a notice to start.

2. *Two* taps of the gong, when the engine is standing, is a notice to call in the flagman.

3. *Two* taps of the gong, when the engine is running, is a notice to stop at *once*.

4. *Three* taps of the gong, when the engine is standing, is a notice to back the train.

5. *Three* taps of the gong, when the engine is running, is a notice to stop at the next station.

One tap of the gong, when running, will be regarded as a warning that the train has parted, and the engineman will follow the rule prescribed for that emergency.

LAMP, HAT, OR HAND SIGNALS.

6. Swung across the track is a signal to stop.
7. Raised and lowered vertically is a signal to move ahead.
8. Swung in a circle is a signal to move back.

ELECTRIC SAFETY SIGNALS.

Electric signals have for years been in use to a greater or less extent on the railways of this and other countries, but in many cases have proven themselves unreliable, but of late years the system has been greatly improved, and many railways are now adopting the improved system, which is found to facilitate the movement of traffic with greater safety. It can hardly admit of doubt that in the near future "electric safety signals" will be generally adopted as an absolutely necessary adjunct to efficient and safe railroading.

Electric signalling systems.—There are now two distinct general systems of automatic electric signalling recognized. The *wire system*, in which a line wire forms the main circuit, and the *rail system* in which the main circuit consists of a long section of rails.

The wire system.—The operation is substantially as follows: When the signal section is reached by a moving train, the first wheel of the locomotive *closes* an electric circuit and thereby brings a danger or block signal into view by the direct action of magnetism. The signal remains at danger until the locomotive has run to the end of the signal section, when as before the first wheel of the locomotive truck operates an instrument, completing another circuit which releases the signal in the rear, causing it to show safety or all clear for a following train. This system, although doing good service on several roads, is not considered as perfectly reliable for many reasons, therefore in many cases the rail circuit system is being substituted.

The constant circuit rail system.—This system, controlled by the Union Electric Signal company, has been tested and is in operation on many of the best managed roads in the country, and is regarded as superior to all others owing to its extreme simplicity and reliability.

Essential features embodied in the system.—Automatic block signals, road crossing signals, station approach signals, yard signals, junction signals, broken and torn up rail detectors, hand-key signals, repeaters, and all the various signals, visional and audible, required in railway service.

Forms of signals.—The signals used are of several forms, according to circumstances, and mounted on an iron post operated by mechanism contained in a box below; the target is painted red or white according to requirement; a lamp occupies a position on the top of the shaft for night use, which automatically presents a red and white light alternately as the signals change; the signals are usually arranged to show full face when set for safety, and turned around edgewise for danger.

Operation of the system.—In this system the rails of the track are substituted for the wire as conductors of the electric current, each section or block is insulated from that preceding and following it. The signals are set in blocks or sections of a mile, more or less, and in number as the character of the road may require, a curving roadway requiring more than one with miles of straight track. At one end of the section or block is placed the battery, consisting of a single cell, which will operate through a mile of track, one pole attached to either rail, while at the opposite end is placed the magnet, one electrode attached to either rail, thus establishing a constant metallic circuit through the rails and magnet, the circuit being made perfectly reliable by connecting the rail joints with wire. Experience has shown that the apparatus is perfectly free from atmospheric influences. The rails being metal, of very large cross sections and consequent great conductivity, are vastly superior as conductors to any surrounding media, and hence the electricity adheres to the rails and keeps the magnet magnetized, even during the heaviest rain or snow, in preference to passing off into the earth. The magnet keeps the signal indicating "all clear" as its normal condition, but when a train enters upon the section the wheels and axles short circuit the current, because they are better conductors than the small wire of the magnet; and the magnet being thus demagnetized, releases its armature and the signal is instantly thrown to "danger," and remains there as long as any part of the train is on the

section or block, warning all after comers to a halt. Tearing up a rail, or breaking one, interrupts the electric current and the signal goes to "danger," and it is impossible for it to say "safety" until the damage is repaired. Should the battery be too long neglected, go to sleep, say, at its post, like some human watchman, or become broken, "danger" is the signal until "safety" is established. In brief, so long as the current of electricity is maintained and the track is clear, the signal says "safety;" interrupt that current by placing rails across the track, running a train upon it, or leaving a car on a block, and the signal is instantly thrown to "danger." To these admirable arrangements for safety can be added an interlocking switch system, drawbridge, crossing, and station approach signals.

Overlapping or distant signals.—These are connected with the primary signals and overlap the sections in both directions. The signals on the right hand side of the track answering for trains going in one direction, and those on the left hand side for trains going in the other direction, both being notified by distant signals of the condition of the section in advance.

The interlocking switch.—The switchstand is provided with a special lock, under control of an electro-magnet in such a manner that, when the magnet is demagnetized, the switch is locked and cannot be opened by any one in the ordinary way. The switch-locking magnet is connected in a secondary circuit with the rails of the block system, and is operated in connection therewith, and controlled by the approaching train. Provision, however, is made for controlling the switch magnet by means of a hand key, when it is necessary to do so, but this can only be done by maintaining a danger signal at a certain distance from the switch when it is opened to let a train enter upon the siding. This interlocking arrangement fully provides against the opening of a switch in the face of an approaching train, as the danger signal must be shown before the switch lever can be moved. To provide against the bridle-rods of the switch making electrical

connection between the rails, they are cut and insulated, or the switch-rail is otherwise cut out, a joint is also insulated in the crossing rail. The Pennsylvania railroad has found an arrangement of this kind necessary, and the interlocking switch and *signal system*, as there exhibited, is the result of the diligent labor during many months of the best railway minds of Europe and America.

SECTION XLVII.

NUMERALS AND ABBREVIATIONS.

Upon many lines the most extended and ingenious ways are sought to abbreviate and save time. Hence certain numerals and abbreviations are made use of to convey some special information, while others serve to furnish an answer. Although there exists to some extent a diversity in the meaning of some of them on different lines, the following numerals and abbreviations are more or less in common use.

NUMERALS.

1. Wait a minute.
2. Important.
3. Give me correct time.
4. Where shall I go ahead.
5. Anything for me?
6. I am ready for business.
7. Are you ready?
8. Keep circuit closed.
9. Train dispatcher's signal—preference over all other business.
10. Be ready to take the standard time.
12. Answer how you understand, and get my answer before starting.
13. I, or we, understand.
15. Message for all offices.
17. Do you get my writing?
18. What is the trouble?
19. Give me report of—
20. Repeat this back.
22. Busy—on another line.
23. Accident or death message.
25. Your car statement is wanted.
26. Put on G. W.
29. No circuit beyond me, my G. W. on.
30. Finis. The end.
31. How do you understand?
33. Answer prepaid.
34. My instrument works badly.
35. Inform all interested.
40. What is the weather?
41. Write slower.
44. Answer immediately.
73. Accept my compliments.
77. I have a message for you.
134. Who is at the key?

ABBREVIATIONS.

A. All.
Ads. Address.
Af. After.
A. M. Morning, Forenoon.
Abd. Aboard.
Abt. About.
Acn. Accommodation.
Agt. Agent.
Agn. Again.
Ahr. Another.
Amt. Amount.
Ans. Answer.
Adj. Adjust.
A. or **Ar.** Train arrived.
B. Be.
Bf. Before.
Bk. Book or back.
B. M. Baggage-man.
Bn. Been.
Bat. or **Btty.** Battery.
Bbl. Barrel.
Bnd. Bound.
Bag. Baggage.
Brk. Break.
Bot. Bought.
Btn. Between.
Btr. Better.
Brkg. Breaking.
Bal. Balance.
Bsns. Business.
C. Can.
Co. Commence, Company.
C. O. D. Collect on Delivery.
C. I. F. Cost insurance freight
C. F. I. Cost freight insurance.
Cd. Could.
Ci. or **Ct.** Circuit.
Ck. Check.
Cm. Come.
Clk. Clerk.
Ct. Connect, cent.
Cmn. Common.
Cur. Current.
Com. Communication.
Cndr. Conductor.
C. & E. Conductor and Engineer.
Da. Day.
Dd. Did.
Det. Detained.
Dg. Doing.
D. H. Free.
Dn. Done.
Ds. Does.
Dw. Down.
D. or **Dep.** Train departed.
E. Of the.
Ea. East.
Eh. Each.
Ev. Ever
Ex, Express.
Ehr. Either.
Eng. Engine
Engr. Engineer.
Evy. Every.
Exa. Extra.
F. Of.
Fi. Fire.
Fr. or **Fm.** From.
Frt. Freight.
Fwd. Forward.
F. O. B. Free on Board.
G. A. Go Ahead.
Gd. Good.
Gg. Going.
Gi. Give.
G. M. Good Morning.
G. P. M. Good Afternoon.
G. Da. Good Day.
G. Bi. Good Bye.
G. N. Good Night, Gone.
Gen. General.
G. W. Ground wire.
Gtd. Guaranteed.
G. B. A. Give better address.
H. Have.
Ha. Has.
Hd. Had.
Hf. Half.
Hi. High.
Hm. Him.
Ho. Who.
Hr. Hear, Here.
Hs. His.
Htl. Hotel.
Hu. House.
H. R. U. How are you
Hw. How.
Hy. Heavy
I. By.
Ik. Like.
Ifm. Inform.
Immy. Immediately.
Inst. Instrument or instant.
Impsb. Impossible.
Impt. Important.
Js. Just.
K. Take, o'clock.
Kg. Taking.
Kn. Taken.
Kp. Keep.
Kw. Know.
Kps. Compliments.
Lv. Leave.
Lrn. Learn.
Ltr. Letter, later.
Ltl. Little.
M. Noon.
Ma. May.
Man. Manager.
Md. Made.
Mk. Make.
Mh. Much.
M. L. Minutes late.
Mo. Month.
Mr. More, Mister.
Mt. Meet, empty.
Mv. Move.
Min. Minute.
Msk. Mistake.
Mtr. Matter.
Msg. Message.
Msgr. Messenger.
N. No, not.
Na. Name.
Nh. North.
Ni. Night.
Nn. None.
No. Number.
N. B. Take notice.
Nr. Near.
Ns. News.

Nv. Never.
Nsy. Necessary.
Ntg. Nothing.
N. M. No more.
O. K. Correct.
O. T. On Time.
Ov. Over.
Obg. Oblige.
Ofr. Offer.
Ofs. Office.
Ohr. Other.
Opr. Operator.
O. S. All offices take notice.
Pa. Pay.
Pc. Place.
Pd. Paid.
Pf. Proof.
P. M. Afternoon.
P. O. Post Office.
Pls. Please.
Ppr. Paper.
Psb. Possible.
Pass. Passenger.
Prst. President.
Q. Question.
Qk. Quick.
R. For.
Rk. Work.
Rr. Repeat. Railroad.
Rs. Raise.
Rt. Right, Write.
Rep. Report.
Rhr. Rather.
Rmn. Remain.
Rtn. Return.
Rlf. Relief.
S. Was.
Sa. Same.
Sd. Should.
Sf. Stop for.
S. R. Yes sir.
Sh. Such.
Sl. Shall.
Sm. Some.
Sn. Soon.
Ss. Says.
St. Street.
Su. South.
Sfb. Stop for breakfast.
Sfd. Stop for dinner.
Sfn. Stop for night.
Sft. Stop for tea.
Sig. Signature.
Sml. Small.
Stk. Stock.
Smtg. Something.
Supt. Superintendent
T. The.
Td. To-day.
Tf. Tariff.
Tg. Thing.
Ti. Time.
Tk. Think.
Tm. Them.
Tn. Than, then.
Tr. Their, there.
Ts. This.
Tt. That
Tw. Town.
Ty. They.
Tel. Telegraph.
Tho. Though.
Tmw To-morrow.
Tnk. Thank.
Tru. Through.
Tkt. Ticket.
Trn. Train.
Thot. Thought.
U. You.
Ur. Your.
Ut. But.
Un. Under.
Und. Understand.
V. Very.
Vg. Village.
W. Will.
Wa. Way.
Wd. Would, would.
Wh. Which.
Wi. With, wire.
Wk. Week, weak.
Wl. Well.
Wn. When.
Wr. Where, were.
Ws. West.
Wt. What.
Wy. Why.
Whr. Whether, weather.
Wrd. Word.
W. & W. Wood & Water.
Wo. Who is at the key.
W. **B.** Way bill.
X. Next.
Y. Yes.
Yr. Year.
?. What did you say? Repeat.
&. And.

SECTION XLVIII.

MOVEMENT OF TRAINS ON SINGLE TRACK BY SPECIAL TELEGRAPHIC ORDERS.

The greatest care and vigilance should be exercised in the receipt and use of special telegraphic orders. Whenever trains are moved by special order, otherwise than as provided in the schedule, it becomes of *vital* importance that *all* the trains con-

cerned should fully understand the orders. First-class, efficient and reliable train-men and operators should be employed on salaries sufficiently good to retain their services. Usually men who have the largest responsibilities in the way of human life and comfort are paid beggarly wages. Trains should be run by time-cards as far as possible, and no special orders issued unless absolutely necessary. There should be a uniformity in train orders, so that conductors and enginemen changing roads may be conversant with each and every order they may receive. More attention should be paid to the registering by conductors at junctions. More side tracks and telegraph stations as a rule, so that trains can clear each other with but little delay, according to schedule rules; or, where a special order is given by telegraph, the dispatcher can have an understanding from all the parties interested in the change before any train proceeds to make it. Most roads might avoid a good deal of the dispatching now found necessary by a *careful adjustment of time cards* and giving *slower time*, particularly to heavy trains. In the anxiety to get the most work out of the rolling stock time is often made too short, which renders train-men liable to become nervous and excited and impatient, and they commence to call and clamor for the dispatcher, and the result is, some one or more of them forget some order and disaster follows.

"System and discipline are the best and most trustworthy guarantees of safety in railroading. Without them a perfect equipment is valueless."

The present system of train dispatching, although ordinarily satisfactory, if properly used, often provides little or no check upon the individual.

"The weak point of the system is that important movements are intrusted to the hands of single individuals, or to two persons similarly circumstanced (for example, conductor and engineman), so that if they blunder, the error often goes on to result without chance of detection."

"In each case of accident the fault can usually be traced to one or more individuals who disobeyed some order or neglected some precaution. It may therefore be said that the *individual was at fault* and not the system, but it must be remembered that the system is, or should be, devised to keep *a check upon the individual.* Human agents can never be infallible, and the very best wiil sometimes err. The most competent may, under certain unforeseen circumstances, become totally incompetent. If these agents never made mistakes no system would be needed, but as the individual cannot be prevented from doing wrong *a system is necessary* which will reduce the liability to err, by *inducing regularity*, and when an error is made *detect the error as soon as made*—a system is good in proportion to the *rapidity* with which it *corrects* the *mistakes of individuals*, and no system can be called cumbrous which *absolutely prevents an incipient error* from going into operation."

This branch of railroading does not seem to be recognized as the important part of the service which it really is, and few superintendents give it the careful attention it should have.

SPECIAL ORDERS.

Meaning of " orders " and " schedule."—The word "orders" in this connection means "telegraphic train orders," and the expression "running by schedule" means running according to the time table and the rules printed thereon or required to be observed therewith. All trains and engines are run by schedule unless otherwise directed by orders from the office of the division superintendent. A train order takes the precedence always, and, on the arrival of a train at the point designated in its orders, unless the order is renewed, it falls back on its rights as given in time schedule.

Uniform system.—In the movement of trains by special orders there is *no uniform system;* nearly every road has a system of its

own differing from the others in details, and often on the different divisions of the same road the manner of giving and receiving the train orders is different. However, the *principles are common* on nearly every road in the United States and Canada.

Trains, how designated in orders.—Regular trains are designated by their time table numbers; irregular trains usually by the word "extra" or "special" and the engine number, and engines without trains by the word "engine" and its number, and any other trains by such names as may be necessary to fully designate such trains. On some roads for a train under flag is added "flagged by" and the designation of the flagging train.

Train number.—Many roads require the train number to be displayed on the caboose. "The plan of the Lake Shore road, which requires the train number to be displayed in the tower of the caboose, which is plainly visible both by day and night, is particularly commendable in the fact that it shows both the number of the train and the section plainly and unmistakably through the rear windows until the "tail" lights grow dim. The Baltimore & Ohio road also take the precaution to have the numbers of their engines placed in very large figures on the tenders. This aids the operator as well as those on passing trains to distinguish more readily a train, which is identified by its engine number." As an additional precaution, it has been suggested that the *number of the train* be inserted at each side of the headlight immediately in front of the reflector. It has also been suggested "that each caboose be provided with a box or deck (a movable box for trains without a caboose) showing from the front and rear the number of train, section and signals. If no signals the device should be so arranged as to indicate "no signals."

Train wire.—The line or wires chiefly used for directing the movement of trains by telegraphic order.

Address of orders.—All special orders for the movement of

trains are sent through a station operator ; the most common practice and the safest one, addressed to both conductor and engineer. On some roads the name of the conductor is given in full, while on others the order is addressed to conductor only, a practice not to be commended, although the mode of procedure is essentially the same, as both conductor and engineer must have copies thereof, and fully understand the order, before leaving a station. The number of the train and place where the order is to be delivered are also included in the address.

Agents addressed.—On some roads train orders are addressed to agents to hold such train as may be required, for orders, who will sign and answer the same as conductors, for the faithful performance of such orders. They are held alike responsible with the operator. This is to relieve the operator from the necessity of leaving his instruments to attend the signalling of trains for orders.

Train orders to agents, or other station employes.—Whenever an order is sent to an agent, operator, or other station employe to hold any train for any purpose, the order must be as strictly observed as if addressed to conductor, or conductor and engineer. Station agents, operators and others will, in such cases, deliver copies of the order received, to conductors and engineers, and this will be done even when the train for which they were held has arrived.

The body.—When practicable only one transaction should be included in the body of a "single order," and no instructions should be included that are not strictly running orders. While on many roads only the *number* of the train is stated or given in the body of the order, on others the number of the train and engine number are both given, similar to that practiced on the Wabash system of roads; while on others the number of the train and also the name of the conductor is given, and as an extra precaution it has been suggested to add the engine number to the latter.

"If the train order gives number of train, name of conductor and number of engine, then certainly there can be no excuse for failure to identify, especially if both engine and train number are conspicuously displayed." This would, however, add to the work of the dispatcher, and necessarily make matters more complicated without perhaps being any particular advantage.

Abbreviations and signals.—All orders must be written in full, and no abbreviations used except the initials of the superintendent or train dispatcher, C. & E. for conductor and engineer, OK. for correct, and the numerals 12 and 13, meaning respectively, "answer how you understand and get my answer before starting," and "I, or we, understand." The abbreviation "ans." is used on some roads instead of the numeral 12.

Precaution in sending orders.—Before an order is sent by telegraph to give a train order to proceed against another having the right of track, an order must first be sent to the train having the right, or an order placed ahead of it to hold it for orders, and get a reply, whenever it can be done, before giving orders to another train to run upon its time.

"*Rights*" *conveyed by special orders.*—A special order is never to be considered to mean anything but what it plainly expresses. Special orders give no special rights whatever against any trains *except such as are distinctly named therein.* Trains moving by special order against certain specified trains must be governed strictly and entirely by their schedule rights as *against all other trains not specified.* A train having a special order *up to a specified time*, upon the expiration of said time is governed by their schedule rights. Telegraph orders must be carried out implicitly so far as they relate to the trains named in them. An order to run regardless of a certain train refers to *that train only.* An order to meet and pass another train at a given point gives no right whatever against any other trains coming or passing.

Special orders regarding sections of trains.—In moving trains

by special order each section, or engine, is taken and considered as a separate and distinct train, and receives and runs only under special orders addressed to its own conductor and engineer. The orders specify the trains to which they refer, and do not affect trains or engines which may be following signals on the leading trains, unless such following trains or engines are distinctly stated in the special orders.

Blanks.—All special orders must be given in writing and written on the blanks (or manifold paper) furnished for that purpose, printed forms in which blank spaces are left for the parts which are variable are furnished by some roads, but manifold paper is used on most roads, furnished in book form. Some roads use different colored paper or blanks.

Manifold paper.—The use of manifold paper for orders, by which as many copies as are required are made at one writing, and all exactly alike, has become quite common. It not only saves time but it insures the identity of the order. On some roads, for convenience, the manifold paper is prepared in packages and marked 3, 5, 7, etc., as the case may be, so that the operator can, on the instant, be ready to copy as many as the dispatcher may request.

Manifold paper, how used.—A sheet of tin is, or should be, provided for the purpose, upon which are laid alternate sheets of thin yellow or white, and carbon paper, the yellow being generally used. The carbon paper should never be written upon, but placed between the yellow sheets, and the impression taken by writing on the top sheet with a stylus, or a good No. 3 or No. 4 pencil.

As the thin yellow sheets of manifold are objectionable to handle in many cases, a white paper of more body is often used to advantage.

Numbering orders.—On the majority of lines special orders are numbered consecutively, for one day, week, or month, com-

mencing with No. 1 immediately after midnight. In answering an order, when numbered, the operator should in all cases begin by repeating the number of the order.

Methods of sending special orders.—There are two distinct methods of sending orders, some roads practicing one and some the other. The common plan has been to send the order to each train concerned, separately, but in the "duplicate" or "double order" system the dispatcher calls up both offices where orders can soonest be delivered to the trains concerned, and sends the order to each at one writing, the orders worded so that the same one serves for both trains. This system is considered to be the most reliable and less liable to error, although the advocates of the old system claim, with a good schedule of rules, and train men who understand them thoroughly, the shortest form of train orders, which will embrace what is required and be understood by all, sent separately to each train concerned, is the safest and best. However, the latter system has several serious defects, among which may be mentioned the liability of giving to one train a meeting place different from that given to the other; hence, the mental strain is very great in the mind of the dispatcher; especially so with men of moderate skill, who have ever the feeling that an error may be or may have been committed. No system can be regarded as safe that leaves *any chance* for an error or accident to happen, either through inexperience, forgetfulness, bad handwriting, or any other cause.

Objections to the double order system.—Although the plan is acknowledged to be a superior one, it is claimed it cannot be worked to advantage on some roads, for instance, where, as it is often the case, a large number of operators are also station agents and have other duties to attend in and out of the office, it would be, perhaps, seldom both offices could be made to respond just at the same time, and would consume more time in the end than the old system of sending each order separately. However, "when practicable, orders (for two or more trains) should

be sent to each train at the same time, but the order to the train having the right of way should always be made complete first."

Advantages of the duplicate or double order system.—This method of orders possesses many practical advantages over the old system, and seems to be the result of necessity and experience. Its worth is demonstrated by the fact, that a large proportion of the leading railways of the country have now adopted it, and the system will undoubtedly in time come into general use. Among the points in its favor may be stated that the mental strain arising from the other method is in a measure entirely absent in this, which alone must at once commend itself.

"In preparing this order the dispatcher cannot possibly give different meeting points, as there is but one message for both trains, and being transmitted to both simultaneously each must get the same as the other." Besides this, each operator who copies the order very naturally listens to the other's as the understanding is being repeated, and thus still more adds a valuable precaution against error. Some observe the commendable practice of underlining each word as repeated back. When several meeting points are named in an order, each train named, whether directly affected or not, is made familiar with the general programme and meeting places.

Probably no road in the Union makes better use of the telegraph in the moving of delayed trains than the Pittsburgh, Fort Wayne & Chicago, as the trains are numerous, and it requires close figuring to get a delayed train through without detaining others. The system of "double orders," as practiced on this road for several years, is found to be in every way satisfactory and much preferable to the old system.

Transmission of orders.—The common form of procedure is as follows: The train dispatcher calls up each office separately, if to be sent to each train separately, or both offices if to be sent to each at one writing, and first gives the special signal indicating that a train order is to be sent (the signal varying on different lines, the numerals 12 or 31 is probably more generally used) after the signal the word "copy" should follow, and the number

indicating how many copies are to be made if more than three are required. The order of transmission is then as follows: *First*, the number; *second*, the place from and date; *third*, the address; *fourth*, the body of the order, which must state in clear and concise form the exact thing to be done; *fifth*, the signature which is either the initials of the train dispatcher alone, or annexed to those of the superintendent, followed by the initial of the operator sending if not transmitted personally by the dispatcher.

Repeating back orders.—Special orders, when communicated by telegraph, should be as soon as possible *repeated back* to the office, from which they were received. If the train has arrived the order should be read aloud by the operator, in hearing of the conductors and engineers or others to whom the same is addressed. Such conductors and engineers or others if they understand it, must then personally sign their own names below said orders. The operator will then repeat the order back to the train dispatcher, word for word, as originally sent, with following changes: Instead of "from dispatcher's office," say "from their own office," addressed to train dispatcher, and commence body of order by saying 13, (meaning I or we understand), repeat the body of order, then give as signature the names of the conductors and engineers or others addressed. No alterations or erasure must be made; if it becomes necessary to make any change, except as above, in the first copy, the dispatcher must repeat the entire order, and a new copy be made by the receiving operator.

"If a train has not arrived—as is the case many times every day, where a dispatcher anticipates orders—the operator repeats the order back to the dispatcher precisely as received, and on the arrival of the train secures the understanding from the conductor and engineer, and transmits the same to dispatcher as soon as possible thereafter.

Repeating back, when the order is sent to both offices at the same time.—If both are ready to repeat back at once the one receiving the order for the superior train, or for the train first named in the address, generally has precedence; otherwise the first one ready will repeat first. However, this should be fixed by rule.

The repeating back must be done in all cases by reading from the copy that is actually to be delivered. Neither copy must be delivered until both operators know that "correct" has been given to both offices, and each office should read the repeating done by the other that any discrepancy may be doubly guarded against.

When both offices are not on the same wire, the main office will inform each when the other has received "correct," and when one order is to be delivered at the main office, the other will assume that it is correct there, as orders to be delivered at the main office will be duplicates of the corresponding orders sent to other offices.

The completion of orders.—When a special order has been received and repeated back the order is not complete until the dispatcher's acknowledgment is telegraphed back, and noted on the order; if the understanding is correct the dispatcher usually responds by giving the "number" of the order, "OK," "correct," or "all right," and correct time over his signature, (the reply varying on different roads), probably the word "correct" is most generally used. The operator then writes the reply on the order affixing his own name (or initials) beneath it, and delivers copies to conductor and engineer, or to whoever addressed, retaining one copy in the office, and then arranges the signal so as to allow the train to proceed.

Importance of the word "correct."—No order is of any value without the word "correct" written upon it, and operators will under no circumstances deliver orders until dispatchers authorize them to indorse them so correct. In order to save time and allow the operator to get copies ready, the dispatcher may send

an order a short time before it is intended to go into effect, as he may desire to have an understanding from another conductor in the meantime. Hence the word "correct" is of very great importance.

As a precautionary measure against accidents the management of several roads have recently issued instructions to the effect that, when special orders, supplements or notices are received, involving the safety of trains, the engineman shall see that his fireman reads and understands them. And the conductor shall see that his baggage master, or, on freight trains, a reliable brakeman, reads and understands the same. Firemen, baggage masters or brakeman, having read orders as above, must keep them in mind and must be prepared to correct any mistake which comes under their observation.

Diversity in the practice of repeating back and verifying orders.—While it is the practice on some roads to defer the repeating until the signatures of the trainmen are secured, on others, whether the train is at the station or not, each operator in turn who receives the order, immediately repeats it verbatim to the dispatcher, securing his "OK," and afterwards secures the signatures of the trainmen or whoever addressed, and transmits them to the train dispatcher in connection with the train number or destination, who then acknowledges same in some prescribed form, using "OK," "correct," or "all right," followed by his signature, which must be endorsed on each copy with the exact time it was given, when the order is then ready for delivery. The latter method is preferred for several reasons. When a dispatcher has a great many trains to handle it is quite obvious that much time is saved by repeating back the order and holding the operator responsible for securing correct understanding and signatures of the trainmen, as against the system of invariably holding a train for the conductor's understanding to be transmitted and dispatcher's "OK" secured, for the reason that a dozen trains might be waiting at as many stations at the same time for completion of their orders. Another advantage in this system is in case of interruption to line all orders that *have been given are verified*, and trains can act upon them accordingly.

Interruption of line.—When, by reason of the telegraph failing, or other cause, the understanding cannot be sent, or the "correct" returned, the *order is void*, and must be so considered by all concerned, "but a reasonable time should be allowed for communication to be restored, before allowing the train for which the order is designed to proceed without it."

Repetition of the same order for different trains.—Operators having the same order for a number of different trains or sections need not repeat the order for every train or section, but after sending the reply once and getting the "OK" to it, can then add the balance of the signatures, giving the number of the order before each signature, and getting the proper "OK" for each.

Delivering orders.—Operators are not required to leave their instruments to deliver orders, unless in case of emergency the dispatcher so directs. The conductor will go into the office and receive and receipt for the orders there. Operators are, however, held strictly responsible for the safe and correct delivery of an order, and must personally deliver all orders received by them unless relieved from such duty by special permission of the train dispatcher.

On some roads the conductor is required to sign the understanding of the order, and, after receiving an order, will, as soon as it is endorsed "correct," *personally* deliver to his engineer a copy of the same, retaining also a copy for himself, in which case they must compare their copies to see that they agree, and that they understand them alike.

Operators in train dispatchers office.—They are not permitted to give an "OK" to train orders until directed to do so by the train dispatcher, and in sending special orders and answering "OK" to the same, they are required to annex their own initial letter to those of the superintendent and train dispatcher.

Copies of orders.—A copy of every order to any train must be held by the conductor, the engineer, and the operator deliv-

ering it, and to insure correctness, and save time, the three copies should be made at one writing by the use of manifold paper which should be so arranged that three impressions or more, if required, may be taken. When an order affects two trains, the order as given to one must be an exact copy of that given to the other.

Signatures.—Operators must sign all orders they deliver, and get, on the copies they retain, signatures of the person to whom the orders are delivered.

Orders copied in a book.—Generally operators are required to copy all orders in a book provided for that purpose, and record on the margin of such orders the initial letter of operators receiving or sending such orders, together with the correct time received or sent. The copies of orders retained by operators should remain in the book, and finally be sent to headquarters for inspection.

Breaking circuit.—No other operator is allowed to break circuit, while a train order is being sent, unless authorized to use the proper signal, which entitles him to the circuit.

Numerals.—In sending, writing, and repeating back, all numbers of trains, engines, and switches, excepting those in the address of an order, should be written in words followed by the figures. The word "hundred," however, may be omitted, thus: "engine five ninety-two (592)." On some roads the numerals are simply represented by figures, and on others, the figures are duplicated with a comma between.

Orders for train not arrived.—An order received for a train not arrived must, when folded, have the train number marked on it and be placed in a conspicuous place before the operator to await the arrival of the train.

Precautions when orders are awaiting an expected train or engine.—On roads where the proper train order signal is only displayed when orders are awaiting an expected train or engine, on

receiving a train order the operator must at once display the signal, whether the train for which they have orders is at their station or not, and then reply that such train is held. When this signal is displayed at a station every train arriving must come to a full stop, and the conductor and engineer report at the telegraph office without delay for orders; however, operators should be careful not to signal a train for which they have no orders, but should they do so, they are required to give the conductor a written notice that it was an error.

Operators must watch closely for expected trains, and in case a train or any part of it has passed a telegraph office they must not depend entirely on the proper signal to hold the train for orders, but watch carefully that engineers see the signal or at once find the conductor and call his attention to the displayed signal. In case of fogs or severe storms torpedoes should be used, which are provided by most roads for that purpose. Opertors should remember that this may be a matter of life and death, and leave nothing undone to insure safety; they must see that the signals are prominently displayed, and observe that cars on sidings do not obstruct the view, or in case of a flag or lantern being used, that the wind does not blow the flag down or extinguish the light. The absence of signals at telegraph stations does not, however, excuse conductors from inquiring if any orders have been received for them where their trains stop regularly.

When operators have orders for more than one train, requiring a continuous display of the signal, trains not affected by the orders may leave the station while signal is displayed, on receiving a release from the operator on the form provided for the purpose.

When all orders are made complete and delivered, for which the signal was displayed, it must be taken in, and no train must leave the station until this has been done, except where conductor has received a release on the proper form.

Duties when the normal position of the signal indicates danger.—On roads where the rules require each office, while open for business, to keep the *normal position* of the signal at danger when orders have been received for any train, the operator is usually required to stop all trains of the same class for which orders are given until the order has been delivered and properly acknowledged, giving clearance orders in each case to trains not affected. When a train approaches a telegraph office, and there are no orders, and all other trains have cleared the station the specified time, the danger signal must be withdrawn, but only between the time the train whistles for the station and the time the rear car of the train has passed the telegraph office a certain distance. Trains will be considered as having passed the station when the *rear of the train* has passed the telegraph office, whether on main or side track. In case a train stops on side track without rear car having passed the telegraph office, the danger signal must be displayed at once and trains must be governed accordingly. Where offices are so located that a view can be obtained of the track, operators must look out before trains approach and see if the track is clear and switches properly set.

Precautions where offices are closed at night.—At offices where there are no night operators, the signal must be fastened by the day operator at safety, before closing the office, and light extinguished between the hours of 7 P. M. and 7 A. M., unless through some emergency it is necessary to keep office open; in which case the signal must be used the same as at other offices, and will be observed accordingly.

Orders to a train to run upon the time of another train.—When necessary to give a train an order to run upon the time of another train, and before an answer can be had from the train having right to the road, an order must be sent to the agent and operator, or watchman, or other employe and operator at the station, to *put out red signals and hold the train for orders*, and

their reply received before giving the opposing train any orders. The parties addressed are required to remain on duty until the arrival of the train, which they are to hold, and *both must know* that the train has received the orders awaiting it before allowing it to proceed. If there are not two responsible employes at the station, the train having the right to the road should receive and reply to their order before sending an order to the latter named train. On some roads, however, when there are not two persons in attendance at the station, the operator is directed to display the signal, and train orders given, on receipt of his answer, signed by him alone.

"On the subject of time orders there is a diversity of opinion. It is claimed by some that if the order be correctly conveyed to both trains, in the same words, there is no more danger than attends the running by time-card, and that the giving of a time order not only relieves the dispatcher, but makes train-men more prompt in their movements at stations, knowing that idling a few minutes may detain them an hour, and prevents the detention of a superior train by an inferior one. While the time order undoubtedly possesses advantages over the absolute order, the general feeling seems one of mistrust regarding the former—a feeling that its peculiar advantages scarcely compensate for the possibility of error; and in no case is the giving of time orders to trains of equal class practiced." Much risk in time orders arises from the possibility of train-men having variation of watches.

Five minutes for variation of watches.—Whenever any train is held by special rule or order, until a certain time, at any time, for the arrival of some train or engine moving in the opposite direction, it must invariably wait at the point designated *five minutes for variation of watches* beyond the special time, should the train for which it is held fail to arrive. The approaching train must not use any part of these five minutes. This five minute rule must be fully observed, whether the order holding the train be addressed directly to conductor and engineer, or to agent, operator or other station employe.

Trains detained or held between telegraph stations.—No wild or extra train or engine is permitted to run on a railway without the knowledge of, and under instructions from the dispatcher, except

where a train or engine has been detained at some point where no telegraph orders can be got, and when, from any cause, it has lost its right to the road. In such cases the conductor may require the first train passing in the same direction to carry a red signal on its engine for him, provided he is ready to follow immediately, which will give his train the right to follow the train carrying the red signal to the next telegraph station only, where he must ask for orders. Regular trains which have lost their rights on track can also require a passing train, of the same class to carry a red signal for them under the same regulations. The conductor of train carrying the red signal under such circumstances must report the fact to the train dispatcher at the first telegraph station immediately on arrival, naming the point from which he has flagged the other train, unless the normal position of the signal stands at "danger." On receiving the report, the telegraph operator must display the proper signal and keep the same in view until the flagged train arrives.

No night operator.—Should a train be held at a telegraph station where there is no night operator, the conductor may call the day operator into the office to get orders for him.

Starting of trains after receiving orders.—Trains are required to start immediately after receiving an order authorizing them to do so, unless unexpectedly detained, when the fact must be promptly stated and new orders obtained. Going to meals will not be allowed as an excuse for delaying a train either before or after getting orders. Early notice should be given of the expected starting time of trains being prepared and wanting orders. No train, however, is allowed to leave ahead of schedule time.

SECTION XLIX.

FORMS OF TELEGRAPHIC TRAIN ORDERS.

In successful train dispatching economy of time is an important feature. Uniformity and simplicity of orders is a necessity. "Simplicity implies brevity," and the necessity for brevity also brings about a necessity for rules explaining their intention. On most roads one of the best safeguards has been the adoption of *certain prescribed forms*, under which orders shall be given, "and it is found to economize time, and to add to the efficiency of train men to embody, in a set of rules which the men may study at their leisure, positive directions how to act on each of the usual forms of orders, rather than to burden the wire by repeating such directions in the body of each order, and thus give the men no opportunity to read them except when so occupied as to be liable to give them but a passing consideration." The prescribed forms differ in some details on different roads, and are either lettered or numbered, as form "A;" form "B," etc., or form "1," form "2," etc., etc.; and are, as a rule, adhered to: "but it is one thing to prescribe a stereotyped set of train orders; quite another thing, and perhaps the more difficult, to see to or insure their practical working. The forms prescribed may be ever so commendable, yet there is a doubt if they can always be adhered to and a still greater doubt whether the train dispatcher will follow them," as he generally favors the practice to which he has been accustomed.

Classification of forms.—Orders may be classified as follows: "meeting point orders," "regardless orders," "time orders," "passing point orders," "signal orders," "holding orders,"

"orders annulling trains," orders to run wild; annulling an order, etc., etc.

FORM OF TRANSMISSION.

The following "example" of a train order as transmitted, including date, address, body, and signature, will serve as an illustration of the usual method and form of transmission of all others herein presented. Usually *only the office call* is given in the date and address, instead of spelling out the name of the place.

Duplicate order making a definite meeting point.

ORDER No. 1. [Fr.] Cleveland 10.

[To] C. and E. { No. 2—Alliance.
No. 3—Kensington.

Trains No. two 2 and three 3 will meet at Earlville—12.

(Sig.) J. P. A.

For instructions regarding the transmission, repeating back and completion of orders see Section XLVIII.

PRESCRIBED FORMS.

Owing to the lack of uniformity in the forms as practiced on different roads, no general forms can be given that will apply to all roads. However, with perhaps some variation in details, one or more of the following examples, for the cases described and ordinarily occurring, are practiced on most of roads, and required to be observed precisely in accordance with their plain meaning. As a rule the orders are sent on most of roads, when practicable, to all the trains affected by them, at one and the same time; but notices of obstruction to track, repairs of bridges, or other matters which cannot be expressed in the prescribed forms, are sent to trains in such forms as may be necessary to cover the case.

FORMS OF TRAIN ORDERS. EXAMPLES.

Form "A"—order making a definite meeting point.—

First Example.

Trains numbers............and............will meet at ....

Second Example.

Train No........... conductor........................ and train No......... conductor........................ will meet at...........................

Third Example.

Train No......... engine........ and train No......... engine........ will meet at.........................

On this order the trains named will run to the point named; the train arriving first waiting until the other arrives, unless they receive another order authorizing their train to proceed.

Form "B"—regardless orders.—

First Example.

Train No......... will run to....................... regardless of train No.........

Second Example.

Train No......... will run from....................... to....................... regardless of train No.........

Third Example.

Train No......... conductor...................... will run to........................regardless of train No....... conductor.........................

On this order the first named train will run to the point designated, and the last named train must not leave the point designated until after the first named train arrives there.

Fourth Example.

Train No......... will run regardless of No......... it is abandoned to-day.

Form "C,"—Time orders.

First Example.

Train No.........can have until................ to run to .... against train No. ....

Second Example.

Train No......... engine .... can have until .... to go to .... against train No. .... engine ....

Third Example.

Train No. .... conductor .... can have until .... to run to .... against train No. .... conductor ....

On this order the first named train has the right to run to the point designated within the time given; the last named train must not leave the point designated until five minutes after the time named, unless the other train has arrived.

Fourth Example.

Train No. .... can use .... of the time of train No. .... between .... and ....

Fifth Example.

Train No. .... conductor .... can use .... minutes on time of train No. ...... conductor .... to run from .... to ....

On this order the first named train can use so much of the time of the second named train as is specified in the order, to get to the point indicated, or to any previous station. The second named train will run not less than five minutes behind the time allowed the first named train.

Sixth Example.

Train No. .... will run .... late from .... to ....

Form "D"—passing point orders.—

Train No. .... will pass train No. .... at ......
....

Form "E".—Signal orders, or orders for trains running in sections.—

First Example.

Train No......... will carry........signals from........
........to............for............engine........

Second Example.

Engine........will run as..........section of train No.
....

Third Example.

Engine........will carry..........signals, and run from
............to............as........section train No....

Fourth Example.

Train No. ....will carry........signals from........
......to..............for extra passenger train.

Fifth Example.

Train No. ....will carry..........signals from......
..........to..............for extra freight.

Sixth Example.

The........signals carried by train No. ....for engine
..........as..........section will be taken in at..........

Form "F".—Holding orders.—

First Example.

Hold train No. ....for orders or until train No. ......
arrives.

Second Example.

Hold train No. ......conductor............for orders.

Third Example.

Hold train No. ....engine........for orders or until train No. ....engine........arrives.

This order is addressed to the agent or operator who must show the same to the conductor and engineer of the train designated, who will wait indefinitely for further orders, or until the trains specified have arrived. The operator must not give the "13" to such an order unless he has displayed the proper signal, and is assured beyond any doubt he can hold the train as directed in the order.

Form "G"—Annulling orders.—

First Example.

Train No......... this date..........................to .... is annulled. Inform all interested.

Second Example.

Train No......... of.................... is abandoned.

This order is addressed "To all concerned," and a copy must be delivered to all trains interested, and conductors' and engineers' signatures obtained, and transmitted the same as for any other order.

Form "H"—Orders to run wild.—

First Example.

Engine .... will run wild from.................... to......................

Second Example.

Special or extra train No......... conductor........... .... or engine No......... engineer.......... .... will run wild.........................to ....

On this order the train or engine named will run to the point designated, keeping out of the way of all regular trains.

Form "I"—Orders to work trains.—

Work train engine........ will run wild from............ .... to .... and work between .... and.................. to-day until .... o'clock.

If a subsequent order be given moving a working train beyond the limits first prescribed for it, the original order expires, and must not again be used. Conductors must not rely on the orders given by dispatchers cautioning other trains to look out for them, but must use great care in displaying the proper signals warning other trains.

Form "J" annulling an order.-

Order No.......... this date is annulled.

When an order is recalled or annulled as a precaution against error, the substance of the order should also be repeated in addition to the number.

The following forms, as practiced on the Wabash railway, giving second class trains the right to run ahead of, or against first class trains, when circumstances will permit, affords an easy and safe method of moving freight against or ahead of delayed passenger trains:

The following form of order is given the first class trains:

"Train No......... engine........ will run........ minutes behind schedule time from........................ to ....

Upon this order the first class train will run not less than five minutes more behind its schedule time than the time specified in the order.

The following form of order is given the second class trains:

"Train No......... engine .... can use .... minutes on the time of train No. .... engine .... to run from .... to..................

Upon this order the second class train can use the time of the first class train as indicated in the order, to make the designated or any intermediate station ahead of or against the first class train, but not ahead of its own schedule time.

SECTION L.

THE "ABSOLUTE BLOCK" SYSTEM OF TRAIN DISPATCHING AS USED ON THE PENNSYLVANIA RAILWAY.

Of late years railway traffic has been so much developed that the necessity for some efficient system for the movement of trains, that will secure *absolute safety* from collision, has become apparent, hence the "block" system is thoroughly recognized, and is being rapidly developed, and adopted to some extent on many of the more important roads. In England, where a majority of the lines are worked upon the block system, the inspectors of the board of trade speak very conclusively in favor of the early completion of the absolute block system of working on all passenger railways, and that the system should be supplemented by some means of preventing mistakes of signalmen which so often occur and have led to very disastrous collisions.

The permissive block system has hitherto prevailed on most French lines, but the French minister of public works now requires that the absolute block system, with automatic signalling apparatus, shall be as soon as possible established on all double lines.

In this country the public press and public opinion in general are inclined to demand that laws should be passed in every State requiring the compulsory adoption of the "block system" or some other effectual method of giving warning to an approaching train of the presence of other trains on the track be-

fore it, namely, "that, in the case of the double track roads, no train, or division of a train, shall be permitted to enter a section until it has been signaled that the preceding train has passed out at the other end, and the section, or block, is clear; and in the case of single track roads, that trains shall be prohibited from passing specified stations until the exact whereabouts and condition of the train preceding it, or to be met, is known, and instructions received to proceed. Such a law, with heavy penalties to be visited upon every person implicated in its violation, would put an end to most of railway disasters."

The principle of the absolute block system.—"The principle is simply that a railway is supposed to be divided into certain sections, or blocks, of a given length, and no two trains, or engines, are allowed, or ought to be allowed, to be in one section at the same time."

The permissive block system.—Under certain circumstances, this system permits more than one train to occupy a block at the same time, but provides for notifying each train whether the block is occupied or not.

Advantages of the absolute block system.—This system possesses many advantages over any other, and, as used on the Pennsylvania railway, the London Underground road, the Southeastern, the London, Chatham & Dover, the Great Western, and other railways of England and railways of India, is claimed to be the only true and efficient one to secure safety from collision, so far as can be secured by human agency.

On the Pennsylvania railway, east of Newark, over two hundred trains pass over the road daily, and the through express trains often leave Pittsburgh in two and even three sections, so great are the demands made upon them.

On the London Underground road, trains in the morning and afternoon are run at two minute intervals.

On the Southeastern railway the average number of trains at

high speeds through all sorts of crossings, points and junctions, is said to be nearly seven hundred a day. "In India the chief railroads are single track, and operated under this system, and there the operators and station staff are of a very inferior class, in point of intelligence and sense of responsibility. Yet butting collisions are of rare occurrence in that country."

The traffic of these roads is therefore conducted comparatively with safety to the public when the system is thoroughly and efficiently carried out. When operated in connection with the interlocking signals and switches now being adopted, it would seem practically impossible for one passenger train to run into another.

Objections to the absolute block system.—This system must not be confounded with the permissive block system or the block system that has been abandoned on some English lines.

An objection to the system, however, is urged by some, that it is cumbrous, that it would cause delays, that it would cause frequent blockades, and is therefore not adapted to heavy traffic, that the power of moving trains is placed in too many hands, and that responsibility is placed in too many localities, and the telegraph made a substitute for personal diligence and watchfulness, the natural effect being to do away with foresight and the many precautions necessary on the part of practical employes upon the trains, and as an inevitable sequence such employes be made to deteriorate. "The fact that some other lines which are worked without the block system, and which have nearly or quite as much traffic as the Pennsylvania road, have fewer collisions, has been, and is, used as a very effective argument against the block system. That it is conclusive cannot be admitted, but it indicates that there is in such cases something wrong about the application or method of working it on the Pennsylvania road," which may, in a measure, be accounted for by the fact, that the freight traffic is worked on the permissive block system, which permits of several freight trains between two

signal stations at a time; or such accidents may be caused by mistakes of signal-men or inefficient and poorly paid employes, as it is shown by statistics that the most prolific of all causes which produce serious accidents is negligence and mistakes. "It is no excuse for accidents, however, to say that they were caused by the neglect of duty by some employe. That must be expected. The question which a manager ought to answer is whether he could have guarded against the consequences of such negligence." However, "there has been opportunity enough for the public to learn what good railroad management really implies. It is proved better by results than by assertion." The absolute block system has been thoroughly tested, and when thoroughly and efficiently carried out is acknowledged a success by managers who have adopted it.

Expense.—The only valid objection *that can* be raised against the "block" system is its expense, as it is costly to provide and costly to work. Such a system may be expensive, and yet may be more economical than a less perfect and less expensive one. *Surely* the system which is *most prompt* to detect and remedy errors is the safest and most economical to put into the hands of experienced, inexperienced, or unskillful operators. Although costly to provide, the "absolute block sytem" and interlocking signals and switches will in time doubtless be gradually introduced and adopted on all important roads, especially on the most crowded and dangerous sections.

Pennsylvania railway block signal stations.—At the present time there are seventy signal stations between Jersey City and Philadelphia, ten of them being east of Newark, where the trains are the most frequent. At no place on the road does a train run four miles without passing one of these stations. At each one there is a telegraph operator, with three telegraphic instruments, one being used simply for sending general messages; another instrument sends none but signal messages to Jersey City, and the third is connected with only three stations, and is for local

purposes. Fig. 21 gives a good illustration of the "block signal stations."

Fig. 21.—BLOCK SIGNAL STATION, PENNSYLVANIA RAILWAY.

The signal apparatus.—Over the desk upon which the instruments are placed hangs a rope, which runs through the roof of the station, connecting with a wire which in turn is fastened to a glass slide in a square box either above or at the side of the track. Fastened to this slide is a piece of red flannel. There is also a slide arranged with green flannel. In the back part of the box there is a white painted board, in the middle of which is a common lamp, for use at night. When there is no train in sight the red slide is pulled down, showing a red, circular surface, ten feet above the ground, about twenty inches in diameter, indicating "danger;" when the slide is raised a white disc is shown, indicating "all clear." The red signal must be held up by hand, and never secured when raised.

The use of the green signal.—The green signal is used principally to signify that the last train which passed was a freight train and has not yet reached the next station. The use of the green signal advises the engineer to use caution until he has seen a station displaying a white signal.

Distinct circuit.—The system requires a distinct circuit from station to station, and the *constant attention* of the operators to their respective duties.

Elastic.—This system is, so to speak, elastic; that is, it may be made to suit different degrees of traffic, principally by regulating the distances between telegraph stations. Where the trains run close together, the telegraph stations must be close together; where the trains are few, the telegraph stations may be far apart. For instance, the system can be worked perfectly where every *second* stopping place is a telegraph office, in which case, trains, when necessary, can be given orders to meet and pass at the intermediate station or siding. Or the system can be worked to advantage on the most crowded and dangerous sections of a road only.

Operation of the absolute block system.—The system is

worked as follows: No train is allowed to leave one signal station until that signal station has asked leave from the signal station in advance, and such second signal station has replied in the affirmative; and when the train has been allowed to leave, the sending station shall inform the receiving station that the train has left, and the receiving station then is required to acknowledge that he has been so informed. As the train approaches, if the "block" ahead be clear, the operator pulls the rope above his head, raising the red slide, showing the white surface. He is compelled to hold the signal up until the train has passed and displayed two "markers" or green flags on the rear car. He then lets the red slide fall, and "calls" the operator in the station ahead. Having received an answer, he sends the schedule number of the train, the time it passed his office, and states that the green flags were all right.

To be sure he has made no mistake, the receiving operator repeats the message and receives an answer from the operator who sent it before he allows the train to pass his station. Besides warning the station ahead of the approach of the train, a similar record of every train is forwarded immediately to the train dispatcher's office in Jersey City, so that the exact position of every train on the whole road is known at any minute of the day or night. After one passenger train has passed a station no other passenger train can pass it until the operator has received the message from the operator ahead that the track is clear up to that point. So long as the red appears in the target it is evidence that the preceding train is still on that section, and a protracted delay shows that it has stopped or that there is something wrong, and that the waiting train must hold until it gets the word to go ahead.

The "markers"—It has happened that a train occasionally breaks in two, which makes necessary the rule of reporting that the "markers" are seen. At night the system is the same as in the daytime, with the exception that the lamp in the box is

lighted and red lanterns instead of the green flags are used as "markers."

Orders uniform.—A great advantage is that the train orders and messages are uniform; in transmitting them over the wire, they can be expressed in formulæ or signs, all except the number or description of the train, so that the actual transmission of messages occupies but a short time, and there is no chance of misunderstanding.

Provision against errors.—The *absolute* block system provides for a repetition of messages between the two stations regarding each train, and that the train shall not pass until those messages are complete, and on a double track not until the interval is clear, so that, if one operator is negligent, delay will result to the train, which is certain to bring the party in fault prominently forward. Again, if one of the operators makes a mistake regarding the train, there is almost a certainty of its being rectified immediately; that is, as great a certainty as is possible where human agents are employed.

Provision against drowsiness on the part of night operators.—The system is so thorough that trains are even protected against drowsiness on the part of the operators. It checks the danger of a man while asleep allowing a train to pass by, for although he may fall asleep and fail to know that there is a train approaching, the red signal which is always displayed unless raised by the operator, will stop the train, and the cause of the detention must be ascertained. If an operator should fail to report the fact that a train had left his station, it is stopped by the next operator, and the reasons for his not reporting are asked. If no answer is obtained, the central office is informed.

Freight trains.—Freight trains are regulated by cautionary signals, and the train dispatcher in the general office always knows precisely where every train is. Freight trains are not usually run on schedule time, but are allowed to follow each other at

short intervals, depending wholly on the signals displayed; in this way several freight trains may be between two signal stations at a time, and if the last one has passed the first of the two stations some minutes previously, the operator stops an approaching passenger train, states the facts to the engineer, and then raises the green signal, and allows him to proceed; but no other passenger train can go past the station until all the preceding trains, including the passenger, has been reported from the next station. This is an imperative rule, and can only be suspended by an order from the central office in Jersey City, which may have some information sufficient to order the trains to proceed.

Origin of the "block signal system."—The "block signal system" was first originated in the mechanical brain of Mr. Robert Stewart, formerly superintendent of telegraph of the Camden & Amboy railroad, but later of the Pennsylvania. He first saw the necessity of some uniform code of signals, and he was first to think of utilizing the electric telegraph for this purpose. His original system has been since improved upon, until now it is acknowledged as the safest, surest and swiftest system under which trains can be run, and its importance has heen admitted by the managers of the New York Central and other important roads, which have in a measure adopted the plan.

PART SIXTH.

RAILWAY STATION SERVICE.

An authority on railway matters says "that an employe in the railway service cannot become *entirely familiar* with the rules and regulations governing his duties except by acquiring knowledge of the duties of others." Therefore one who does this intelligently and becomes familiar with the different duties connected with the station service prepares and recommends himself for advancement.

SECTION LI.

THE MANAGEMENT OF RAILWAY STATIONS.

The agent.—The business of a railway station is placed in charge of a "station agent," who is under the immediate direction of the superintendent. The agent is required to give satisfactory bonds for faithful service and safe keeping of the company's property and money, the bonds varying according to the importance of the station. Agents are required to strictly observe the rules and regulations of the company governing the business, and to see that employes at the station are at their

respective posts, attending their duties properly, and that all treat the public with courtesy. No agent can conduct the business of a station satisfactorily, if he neglects to pay close attention to the rules adopted for his guidance. "If instructions are *well read* and *observed*," agents will have fewer errors to correct, and many causes for complaint be altogether removed. Therefore, all orders and instructions issued by the company should be *carefully read*, observed, and filed for future reference.

Authority of agents.—They have control of the station houses, sidings and other property of the company, and are charged with the general oversight of same, and employes connected therewith. Operators must respect their authority when it does not conflict with or interfere with their duties as operators.

Authority at large stations.—There is an exception at large points where the different departments are given in charge of, and controlled separately, as "ticket agent," "freight agent," "baggage master," and "yard master." These, however, are all, more or less, under the charge or superintendency of the station agent, the authority varying on different roads.

Yard masters.—They are under the direction of the superintendent, and have charge of the yard and side tracks at stations where trains are made up, the movement of trains therein and of the yard force employed at these points. However, in the absence of a yard master the duties of that official are performed by the agent.

Small stations.—In addition to other duties the agent acts as telegraph operator, express agent, baggage master, etc., etc., and it is often the case has more to look after than any one man should, and do justice to all.

Absent from duty.—Agents are not allowed to absent themselves from duty or leave their stations in charge of others, without special permission from the superintendent.

Classification of station business.—The business of a railway station, under the supervision of the station agent, may be divided into FOUR separate departments, viz: "freight," "passenger or ticket," "telegraph" and "baggage." "Express" may be added on some roads, and at small stations on most roads the station agent acts as agent for the express company.

SECTION LII.

FREIGHT DEPARTMENT.

Freight forwarded.—Station agents must receive, weigh, and give the proper receipt for all goods in good shipping order plainly marked, offered for transportation, except such articles as are prohibited by the rules of the company. In receipting for cars loaded by shippers the receipt must read "shipper's count," "more or less," except where the correct count, etc., is known by the agent. "Releases for household goods and for freight of a similar character must be taken in duplicate."

Loading and unloading freight.—Each lot of freight belonging to different parties must be kept separate. "If goods are loaded in a car for more than one station, the goods to be unloaded first must be put into the car last, and the freight for each station kept by itself."

Live stock.—Agents must require shippers of live stock to sign the "stock contract" issued by the company.

Shipping bill.—When freight is offered for transportation, a shipping bill, giving written shipping directions, must be taken, which should be signed by the consigner or his representative who delivers the freight at the depot, and it is the duty of the agent or tally man who receives the freight to tally same, as delivered, checking each item on shipping bill, and to sign his name under the check marks made by him, after making the

notation "*Tallied when received.*" Freight received from connecting lines is treated in the same manner.

Way-bills.—The way-bill is a blank form designed to insert a detailed record of every consignment of freight. On all freight forwarded from a station way-bills must be made out and delivered to the conductor of the train taking the same (whose name must be endorsed thereon). Separate way-bills must in all cases be made for the contents of each car, and also for goods destined to different stations.

Any special conditions applicable to freight must be noted on the way-bill. In way-billing perishable property, the words "perishable freight" must be noted in red ink on the outside.

Way-bills—how made out.—They must bear the car initials, car number, way-bill number, the date when forwarded, the name of the station forwarding and to be delivered at, the name of the consigner and consignee, the rate charged, and a full description of all articles shipped, and all other particulars, all of which must be entered in the freight forwarded book, and the conductors must, *in all cases*, enter their names in the proper place on all way-bills for freight hauled in their trains.

Copies of way-bills.—At all principal stations way-bills are written with copying ink, and an impression of them taken on tissue sheets, but at smaller stations they are usually rewritten in a record book. As a rule duplicate copies must also be forwarded daily to the proper official at the general office.

Numbering way-bills.—They must be regularly numbered, commencing with No. 1, the first of each month.

Freight received.—On all freight received at a station from other stations way-bills are delivered with same, and the agent is required to critically examine them to ascertain if all footings, etc., are correct.

Personally responsible.—Station agents are held personally responsible for the safe keeping and proper delivery of all goods or property received by them, and for charges due thereon.

Duty to notify consigners.—When freight arrives at a station the agent must notify the consignee by postal card or otherwise, giving amount of charges.

Storage.—If goods are not taken away after five days notice, storage is charged.

Charges.—Before delivering any goods, the agent must make a bill of the freight, and charges thereon, and upon delivery of the articles to the consignee, collect the amount of said bills, which he must receipt when paid. No goods are allowed to be taken away until all freight and charges due thereon are paid. No agent is allowed to give credit.

Receipt for delivery.—Agents are not allowed in any case to deliver goods without taking a receipt for the same in the receipt book provided for that purpose. The receipt of a drayman or teamster will not answer, unless he produces a written order from the consignee.

Unclaimed freight.—On the last day of each month, a detailed report must be made out of all unclaimed freight, and forwarded to the general freight agent.

SECTION LIII.

PASSENGER OR TICKET DEPARTMENT.

Tickets.—Station agents have charge of the sale of tickets at their stations (except at larger points, where a ticket agent is appointed), and are required to furnish all necessary facilities to passengers for the purchase of tickets, having their office open at least half an hour prior to the departure of each train carrying passengers between the hours of 6 A. M. and 10 P. M., except in case of express arrangements to the contrary with the superintendent.

Classification of tickets.—Tickets may be classed as follows:

"First-class," "second-class," "local" or "coupon," "half," "commutation," "excursion," "clergy," and "special tickets."

Supply of tickets.—Agents are required to keep on hand a sufficient supply of tickets to cover all emergencies, and use every exertion to induce passengers to procure tickets before entering the cars, and must give passengers all possible information in regard to time of train connections with other roads, etc. Care must be observed not to sell tickets to stations by any train that does not stop at such station as per time table, but in case of application for tickets to such way stations, they will inform passengers of the proper train to take.

Number.—Tickets are numbered consecutively, and must be sold in regular order, commencing with the lowest number.

Dating tickets.—Every ticket, local or coupon, sold, must be plainly stamped on the back, with the date of sale; always receive the money for a ticket before dating it.

Agents should have a regular time in the day for changing date in stamps. If from any cause a ticket should not be taken after being stamped, and it is necessary to sell it over again, it must be restamped on the day on which the ticket is sold. When the ribbon of the dating machine does not ink readily or has been run through, change the surface so as to bring the underside on top, and when it becomes useless, order another, returning the old one when the new one is received.

Stop over checks.—They are not given on "local tickets."

Ticket case.—All agents who sell tickets are furnished with a ticket case arranged expressly for tickets.

Proper arrangement of tickets.—The proper way to have tickets arranged for selling and reporting, is to arrange them in the order in which the stations are printed; and to avoid labor in going over the whole of the tickets, to examine each ticket each day, have the lowest ticket of every station drawn out sufficiently to see the number. This should be done before com-

mencing to sell. When you sell a ticket do not draw the next one unless to sell it, but leave it out of sight. When making your report you can then at a glance see when tickets have been sold by none being drawn out. Then partly draw out the ticket at every station, take down the numbers in the closing number column on your report for that day, leaving every number exposed as you pass along. You will then have the closing number for that day by having your tickets thus arranged, and observing when no tickets are drawn out. You can, with very little trouble, arrive at the number sold, and your case will at all times be ready to commence sales for the next day.

Agents accountable.—Agents are obliged to pay for all tickets lost, misplaced, or stolen, unless it can be clearly shown that the loss was not the result of want of care on the agents' part.

[Telegraph Department—See Part Fifth.]

SECTION LIV.

BAGGAGE DEPARTMENT.

Baggage.—The wearing apparel, money, and such other articles as are carried for the travelers' use or instruction are baggage, and not articles of trade or for pecuniary profit. "It is not, however, the duty of the passenger to inform the company of the contents of his trunk, unless inquiry be made; but if asked by the proper official he is bound to answer truly."

Amount of baggage allowed free.—Many railways have regulations as to the limit in weight, others as to the limit in value, and some have both. Usually no more than 150 pounds of personal baggage is checked free for any ordinary passenger on a full ticket, nor more than 75 pounds of baggage on a half ticket; and all weight in excess of this amount is charged for at the regular excess baggage tariff rates. No piece of baggage weighing over 250 pounds is accepted for transportation as baggage.

Charge of baggage.—Station agents or baggage masters have charge of all baggage received from passengers (as soon as checked), or delivered to them by train at their respective stations, and must not allow any part of such baggage to be removed without the duplicate check being produced, which must correspond in number and quality of check to the one on piece of baggage claimed. The company is liable for injury to baggage until its safe delivery to the owner, but if left in the baggage-room over twenty-four hours, is subject to storage charges.

Baggage masters' duties.—Baggage masters must require passengers to show their tickets before checking their baggage, and check same and deliver to the baggage master on board the train, and receive from him all baggage to be left at their stations, assist in delivering it to the owners, and keep a record of all baggage received and delivered by them, showing the number of check, date, and number of train. On the arrival of passenger trains at a station, baggage masters are expected to give their attention to the baggage car first, and transact the business necessary to be done with the baggage man before attending to any other, and, in addition to taking charge of baggage, is required to receive, and take charge of, and promptly forward letters and packages on company's service.

Daily reports of baggage.—Station agents or baggage masters are required to report daily in detail to the general baggage agent, accompanying their statements with the way-bills or receipts taken from the train baggage masters.

SECTION LV.

RAILWAY STATION ACCOUNTS.

Books.—Agents are required to enter all accounts of the business at their station in books expressly arranged and designed

for the purpose, which must be written up daily in a plain and legible style, and the accounts in the freight and ticket departments kept entirely separate.

Principal books required.—Cash book, freight books, "freight forwarded" and "freight received," and passenger book.

The cash book, debtor side.—The left hand page, or debtor side, must show in detail the source from which the cash is received. If from freight, it must show the date received, and from whom, date and number of way-bill, folio of freight book, either forwarded or received. If from storage, interest, demurrage, switching, or back fees, it must show the date and from whom received.

The cash book, credit side.—The right hand page, or credit side, must show the disposition made of the money, the amount sent to the treasurer on account of freight, etc., the amount on account of passengers, and the amount paid for charges, if any. Should the cash book show a balance, it should always equal the amount of cash on hand.

Freight books, freight forwarded book.—A full account of all freight forwarded must be entered in detail in this book, and must show the page of the cash book on which each consignment of freight is entered.

Freight received book.—The detailed account of all freight received must be entered in this book, and must also show the page of the cash book on which each consignment of freight is entered.

Passenger, or ticket sales book.—Each day's sales of tickets, both local and coupon, must be entered and kept separate in this book.

Blanks.—In conducting the business of a railway station numerous blanks furnished by the railway company, are required to be filled out by the agent, as per instructions usually given on each.

Reports.—All reports and business of a station are made out and done in the name of the agent. Reports must be made out weekly, semi-monthly, and monthly, on the proper blanks provided for the purpose, and forwarded promptly to the proper official. On all of these blanks full instructions are given and their observance is strictly required.

Cash.—Agents are required to remit daily to the treasurer of the railway company all money received by them from all sources on account of the railway company, deducting only the amount paid for back charges on freight forwarded, and sufficient change to transact business.

Remittances—how sent.—All remittances must be promptly sent by express.

Conforming to official orders.—Any person not willing to conform cheerfully and promptly to such orders as may be found necessary for the proper dispatch of business on a railway is not retained in its service.

SECTION LVI.

EXPRESS BUSINESS—GENERAL INFORMATION.

Express business, has, by the necessities of commerce and usage, become known as a branch of the carrying trade entirely different from the transportation of the large mass of freight usually carried on steamers and railroads. The object of this express business is to carry small and valuable packages rapidly, in such a manner as not to subject them to the loss and damage which, to a greater or less degree, attend the transportation of heavy, bulky articles. It has become law and usage, and is one of the necessities of this business, that these packages be in the immediate care of a messenger or agent. When station agents act as express agents the business is conducted under, and subject to, the rules and regulations of the

express company, except on roads which conduct their own express business; and is eminently one of detail, requiring of all persons engaged in it, system, accuracy, punctuality, watchfulness and urbanity. Hence strict observance of the rules and instructions governing the employes of an express company are absolutely necessary to insure, so far as practicable, uniformity in all departments. An idea of how the express business is conducted may be gained from the following extracts, carefully selected from the rules and instructions governing the service of the American Express Company, whose routes cover twenty States and the Canadas on, 28,000 miles of railroad, with 4,000 agencies—including nearly every prominent northern city from the extreme east to the far west—all under a uniform system of management.

Offices.—Express offices or agencies are designated as "regular" and "non-reporting" offices.

Regular offices.—The more important offices, or those named in the key to tariff without a (*) before them, to which express matter is way-billed direct.

Non-reporting offices.—Offices named in the key to tariff with a (*) before them. At such offices the agent is required to settle with the messenger on receipt and delivery of express matter. A duplicate way-bill must be delivered to the messenger on the train, with all matter forwarded, and a receipt taken; if charges are prepaid, the amount must be paid to the messenger when the articles are delivered to him, and noted on "out book" and on the packages. On receipt of packages or other matter from a messenger, the charges on same must be advanced to him, and the proper entries be at once make in the "record of business received." However, in regard to the business, generally non-reporting agents are governed by the general rules.

Management.—The business and employes of the express company in a city or town are placed under the management and

control of an *agent*, who is subject to the general instructions of the superintendent. Employes are held responsible for any loss occasioned by their own carelessness or inattention, and as no plea of ignorance is accepted as an excuse for mistakes in transacting any part of the business, all instructions issued, and those given in the general tariff book and classification card should be carefully studied. Every precaution must be taken for the safety and protection of *money and valuables*, hence agents are required to make themselves thoroughly familiar with instructions relative to same.

The route agent.—The principal duty of route agents acting under the direction of the superintendents of divisions to which they are appointed is to see, if possible, each and all agents and messengers under their charge *daily*, giving them such instructions and assistance as they may require.

New agents or messengers.—When such are appointed it is the duty of the route agent to see that proper instructions are given them, and for this purpose will remain at the office or with the messenger on the train, as the case may be, until such time as they are competent to attend to their duties.

Opening new offices.—The route agent is required to give instructions as much as possible in writing, by making three or four fictitious way-bills, copying them on "in trip book" and entering one week's business on "out trip book" including packages with advanced charges, prepaid, etc., etc., and any other instructions required in the management of an office.

Classification of express business.—The business may be classified as follows: The forwarding, in charge of special messengers, by fast trains, money and valuables, freight, live stock, corpse, and free matter; the collection business, including notes, drafts, accounts, bills of lading and collections with goods or C. O. D.'s; telegraph transfers of money; the money order system, and the order and commission business.

Way-bills.—All shipments must be properly way-billed according to directions, direct to regular offices or non-reporting offices as per billing directions in key to tariff. The price for each entry must be made on way-bill according to the tariff furnished every office unless it is "free" or "s. c." (service contract) package. The rate per 100 pounds for freight or per $1,000 for currency, to point which bill is made must be entered on every way-bill forwarded.

Numbering way-bills.—All way-bills issued on any one day must bear the same number, and when more than one bill is made to the same office on the same day, the time of departure A. M. or P. M. must be entered on each and so abstracted. On the 1st of January each year the numbering of way-bills must be commenced with number one (1) and thereafter advanced one number for each day on which one or more way-bills are forwarded.

Record.—A proper record of all business transacted must be entered in the prescribed books furnished by the company.

Transfer of property from one employe to another.—In all cases where property is transferred from the custody of one employe to that of another, each package must at the time if practicable be compared with and checked on the way-bills, delivery book, or other list on which they may be entered, and receipts must be given and taken for all way-bills transferred.

Secrecy.—The business of the company and the transactions of its customers through its offices must be strictly confidential, and books, bills, etc., are not open for public inspection. Information concerning the amount of money received or forwarded, or in relation to any matter of business entrusted to the company must not be given to anyone. Secrecy is the main guard and protection of all express business.

Tariff.—A general tariff is furnished at each office and must not be varied from, except by instructions from assistant general superintendent or the tariff department. When offices are opened

and closed agents are promptly notified of same, and must make the proper changes in list of offices and key to tariff, filing the notice for future reference.

Pistols.—Pistols or revolvers are furnished on all important routes, at transfer points, to offices distant from the station, and also to offices where trains are to be met after dark. Each pistol is furnished with a belt, and the agent, messenger, or other representative of the company having money and valuables in charge, must, while on duty, wear the same outside of all his clothing where it can be reached the moment required.

Telegrams.—The telegraph is only permitted to be made use of when necessary to protect the interests of the express company, and never at the company's expense when letters will suffice.

SECTION LVII.

FORWARDING OF EXPRESS MATTER—MONEY AND VALUABLES.

Receipt.—A receipt *in ink* must be given for every money package received, and the package locked up in the safe until checked to other parties.

Marking and addressing.—The exact amount of money contained in packages must be plainly marked on them, and no money package must be receipted for until after it is sealed, nor must the person receipting for it write the address on it unless the shipper thereafter writes his own name on the envelope.

Stitching and sealing money packages.—Pass the string through the centre of the envelope, then around the right hand end, and tie in such manner that the knot will come under the end seal. The above, however, does not apply to large packages (such as bank packages) properly put up in wrapping paper, well tied and securely sealed.

Coin.—Coin in gold or silver pieces exceeding $10, must not

be forwarded in envelopes, but enclosed in cloth bags securely stitched and sealed as follows: Wind the neck of the bag tight, then pass the twine two or three times through the bag with a needle; tie and seal on the knot, and also seal the ends of the twine on the side of the bag, or on the back of the marking tag. However, gold and silver must not be taken in bags in amounts over $5,000 gold or $500 silver. Over these amounts it must be packed in boxes strapped with iron, top and bottom screwed, and plainly sealed with shippers seal, and weight of same marked upon the outside of the package, together with the amount enclosed, and entered upon the way-bill.

FREIGHT.

Receipt.—A receipt in ink must be given on the prescribed form for all packages of every description to be forwarded. Always ask shipper to state the value, and when given (if it exceeds the limit of value fixed by the company's receipts, viz.: $50), enter it on the receipt; mark it on the package, and enter the same on way-bill. If shipper refuse to give the value, enter on receipt, "Value asked and not given." Receipts, however, must never be given for articles to be forwarded without first seeing them and examining marks, etc.

Address.—Goods must have but one address. The street and number of consignees must be given when possible. All old marks should be effectually erased. Cards or tags should not be used for marking shipments, when pen or brush and ink can be applied.

Charges.—When charges are prepaid the person receiving the money must mark the package accordingly, signing his name or initials, and stating whether paid through to destination or only part of the distance, entering same on way-bill. Perishable matter must always be prepaid or guaranteed, and goods evidently not worth the transportation are refused unless the freight is prepaid or guaranteed.

Labelled.—Each package of every shipment must bear the label of the office from which it is forwarded. Packages containing liquid or glass are only received at owner's risk.

Cording and sealing.—Agents are required, at time of shipment, and, if possible, in presence of shipper, to cord and seal all trunks, valises, and hand-bags, using for the purpose, when not provided with stamps for attaching lead seals, the ordinary cord and marking tags supplied by the company.

Extra care.—Boxes and other packages marked "this side up," "keep dry," "handle with care," or with any precautionary request whatever, must be handled and disposed of accordingly.

Specified time of delivery.—Agents are not permitted to contract or receipt to deliver articles in a specified time, nor to deliver goods beyond the termination of the company's express routes. The company can only agree to hand them over to other companies and take their receipt.

Live stock.—All live stock must be receipted for at owner's risk, and charges be prepaid or guaranteed, and releases must be signed by shipper of valuable animals.

Corpses.—Corpses must in all cases be accompanied by a physician's certificate (in duplicate) of the cause of death, etc., which must be pasted on the box containing the corpse and the duplicate attached to the way-bill.

Free matter.—No business is carried free unless under the company's franks, except that of railroad and transportation companies with which the express company are under contracts to carry supplies remittances, etc., without charge.

COLLECTION BUSINESS.

Paper for collection, receipt.—The company's collection receipt must always be given for paper which is received, only from known and responsible persons, to be forwarded for collection. The paper must be enclosed in the proper collection envelope, entering on same the name and address of the party from whom

received and of whom to be collected. All such business must be forwarded and collections made subject to the regulations of the company and the printed and special written instructions on the collection envelopes.

Collections with goods, or C. O. D's.—When bills are taken to be collected on delivery of goods accompanying same, they must be enclosed in the printed C. O. D. envelope for the purpose and the goods marked C. O. D., with the amount to be collected. Any special instructions given by shipper must at same time be written on the envelope. When return charges are to be collected on C. O. D.'s, the proper amount to be collected must be entered by shipping office on the invoice and in the place left for "return charges" on the envelope. The full amount to be collected should also be marked on the goods and entered on the way-bill. Freight charges must be prepaid or guaranteed on C. O. D. goods if they are of a kind and value that would not be sure to sell for double the express charges.

ORDER AND COMMISSION BUSINESS.

Orders for goods or purchases.—In all large cities where the express company have offices, orders for goods or purchases of any kind may be made through the express company without charge, except for the transportation of the goods purchased. Agents are required to give particular attention to soliciting and filling orders and attending to other commissions that may be entrusted to the company. For responsible parties the company will advance the purchase money for orders up to the amount of $5, returning the goods subject to "expense" for the cost of same; when the amount exceeds $5 the money should accompany the order, or the cost of goods can be collected on delivery (C. O. D.) subject in either case to the company's usual money tariff. Order blanks to be filled out by the customer and a special envelope is provided for such business.

Telegraph transfers of money.—Great care must be exercised

in sending and paying money orders by telegraph. Such orders must be repeated back to agents sending them (not to telegraph operators merely), and agents reply as to correctness of message waited for, before payment. Agents must sign their full name, as agent of the company, the same as they would sign an important official document. The expense of telegraphic service must be charged and paid for in addition to the charges for express service. Messages directing such payments must be delivered at the telegraph office by the agent himself, or by an employe of the company known to be such by the telegraph company. When the payee is unknown identification must in all cases be required.

Money order service.—A money order system has been inaugurated by the American Express company, the details of which are very simple, and considered the cheapest, safest, and most convenient arrangement by which a remittance of small sums of money, from \$1 to \$10, may be sent to nearly every part of the Union. These orders are issued at any of the offices of the company, but are only made payable at the more important cities and towns.

Rates.—The rates are five cents for amounts from \$1 to \$5, and eight cents for amounts from \$5 to \$10, which is cheaper than the postal money order rates.

Abstracts.—Abstracts must be rendered to the general accounting office weekly, or oftener, when so instructed, and must show the number, date, and destination of each way-bill issued, and also the total footing of each column on same, viz: "charges advanced," "our charges," "collect," and "prepaid charges," for the time represented on the abstract. The last abstract in each month must end with the last day of the month, thus keeping the business of each month separate.

Messengers' abstract.—Agents are required to return and settle messenger's abstracts in the same manner as their own, enter-

ing name of messenger, and route on which he runs, before the number.

SECTION LVIII.

DELIVERY OF EXPRESS MATTER.

Receipts.—In all cases freight charges and C. O. D.'s must be paid on delivery of shipment, and receipts taken for all articles delivered, giving date of delivery. Receipts for money packages must, in every instance, be written with pen and ink.

Unknown consignees.—When the consignee of a valuable package is unknown, he must be identified by some responsible person, and the person identifying must sign, with party receiving, upon the receipt book. No property, however valueless it apparently may be, should be delivered to a stranger without some reasonable evidence that the party claiming it is entitled to receive it.

"*C. O. D.*" *goods.*—Goods marked C. O. D. must only be delivered, or suffered to go out of the express company's possession on payment of full amount of the bill which accompanies them, except on order from shipper, endorsed by agent at shipping office, and forwarded by express, directing the delivery of goods without collecting bill, or by a permit for partial payment. When consignees of C. O. D. goods cannot be found, or refuse for any reason to receive and pay for the property, post office notices must be immediately mailed to both consignee and shipper. If C. O. D. goods cannot be delivered within 30 days after shipper has been notified, and no instructions are received as to their disposal, they must be returned in accordance with the provisions of the receipt given for the shipment, that the shipper pay charges for transportation both ways.

C. O. D.'s transfer to other companies.—Agents at transfer offices are required to re-envelope all collections transferred to

other companies, retaining the original envelope in their possession until the return of the collection. In filling out the envelope, it must be made in favor of their own company at the transfer office, and great care must be taken to enter thereon all special or general instructions given on original.

Post-office notices.—Every exertion should be made to deliver express matter and not allow it to accumulate. Whenever express matter cannot be immediately delivered, a notice to consignee must be made out and deposited in the post-office on the same day. Such notices must in all cases be addressed the same as the shipment. The date of mailing such notices must be entered on the "in trip book" or "record of packages on hand," opposite the entry of shipment. In case of failure to find consignees by the usual post-office notices or inquiries of persons likely to be acquainted with the inhabitants of the place, or if property is refused, the facts should be communicated to the office from which the goods were received, giving name of shipper, initials or other marks on goods so as to enable that office to get instructions.

Perishable goods.—When such goods are refused by consignee or are not called for, unless other instructions accompany them, they should be at once disposed of to the best advantage, and an account of sales, with net proceeds, returned to the shipper, addressed to the office from which goods were received. In case goods do not sell for enough to cover the charges on them, the deficiency must be "expensed" on shipping office.

Drivers and their assistants.—Drivers are required to receipt for all matter they receive, and are held personally responsible for all matter they receipt for. Delivery books must be checked by comparing with the packages before leaving the office, and charges must be collected as entered in the delivery book or the property returned to the office. Drivers are required to furnish themselves with a list of the company's offices, the tariff to prin-

cipal points, and the classification tariff; also with a copy of "rules and instructions" and be governed thereby.

Statements.—Statements must be returned to the general accounting office monthly, numbered as rendered commencing with No. 1 for the first statement in each year, and must show the totals of each way-bill entered, giving the place from, number, date "advanced charges," "charges collected," "charges prepaid," additions, and deductions. The way-bills should appear on statements in alphabetical order, and after footing each column on the statement a settlement should be made as per the prescribed form showing the cash balance to be remitted to the treasurer of the company. Statements, way-bills, and vouchers for loss and damage, taxes, overcharges, or charges refunded must be enclosed in one package sealed, and so forwarded to the general accounting office.

Origin of the "Express" System.—The "express" business in this country originated in 1839 with William F. Harnden, who, as a public messenger, carried parcels from Boston to New York, and later organized a system of express transportation on a larger scale than had been heretofore known. In 1840 a competing express was started by P. B. Burke and Alvan Adams, and Harnden & Co. established a foreign business and extended their local lines. The formation of several other express companies soon followed, and in a few years consolidated respectively with the "American" and the "Adams" Express Companies. The United States Express Company was established in 1853.

PART SEVENTH

APPENDIX.

SECTION LIX.

STANDARD TIME.

The subject of standard time has for several years received serious attention from scientific men and associations, and the present adopted standard has the emphatic approval of a number or scientific associations, among them the American Association for the Advancement of Science; the American Metrological Society; the United States Army Signal Service; the principal observatories, etc.

The plan was recommended by Secretary W. F. Allen, to the General Time Convention held in Chicago, 1883, and the railways have now adopted it by what may be considered unanimous action, as practically no opposition has been manifested.

Difference in time.—The meaning of the phrase "difference in time" is too well known to require explanation. It is sufficient to say that for every fifteen miles one travels west he will find his watch just one minute too fast; and when he has traveled nine hundred miles, or fifteen degrees of longitude, his watch will be just one hour too fast. The difference in time caused endless confusion to railroads and every one who traveled. To remedy these evils the new plan has been adopted.

The plan of the new system of time standards.—The new system of time is based respectively on the 60th, 75th, 90th, 105th and 120th meridians, as recommended by the General and Southern Conventions.

Under the new system there are five divisions of time on the North American Continent: Intercolonial (not used), embracing Nova Scotia and New Brunswick; Eastern, taking in the New England States, New York, Pennsylvania, and the States south of Pennsylvania; Central, including Illinois, Ohio, Indiana, Missouri and the States north and south of them; Mountain, comprising the roads west of the Missouri river in the mountains; and Pacific, taking in the lines on the Pacific coast.

The railroad officials of the Continent decided to adopt as their standard of regulation the time of the Greenwich Observatory, London, England, and as the longitude in which their roads were situated was so many times fifteen degrees westward from Greenwich, they made their standard of time that many hours slower than Greenwich time. Hence the 60th degree of longitude is four hours slower than Greenwich time; the 75th, five hours slower; the 90th, six hours; the 105th, seven hours; and the 120th, eight hours—thus making five different standards between the Atlantic and Pacific Oceans.

The following table shows the difference between the former time in use and the "Standard time" adopted on the 18th of November, 1883:

COMPARED WITH SEVENTY-FIFTH MERIDIAN TIME.

Albany, N. Y.,	time is	5	minutes	faster.
Baltimore, Md.,	"	6	"	slower.
Bath, Me.,	"	20	"	faster.
Boston, Mass.,	"	16	"	"
Charlestown, S. C.,	"	15	"	slower.
Detroit, Mich.,	"	32	"	"
Hamilton, Ont.,	"	19	"	"
Montreal, Que.,	"	6	"	faster.
New London, Conn.,	"	12	"	"

New York City,	"	4	minutes	faster.
Philadelphia, Pa.,	"	1	"	slower.
Port Hope, Canada,	"	14	"	"
Port Huron, Mich.,	"	30	"	"
Portland, Me.,	"	19	"	faster.
Providence, R. I.,	"	14	"	"
Richmond, Va.,	"	10	"	slower.
Savannah, Ga.,	"	24	"	"
Toronto, Can.,	"	17	"	"
Washington, D. C.,	"	8	"	"

COMPARED WITH NINETIETH MERIDIAN TIME.

Atchison, Kan.,	time is	24	minutes	slower.
Atlanta, Ga.,	"	22	"	faster.
Chicago, Ill.,	"	9	"	"
Cincinnati, Ohio,	"	22	"	"
Columbus, Ohio,	"	28	"	"
Detroit, Mich.,	"	28	"	"
Dubuque, Iowa,	"	3	"	slower.
Hannibal, Mo.,	"	1	"	"
Houston, Tex.,	"	24	"	"
Indianapolis, Ind.,	"	16	"	faster.
Jefferson City, Mo.,	"	9	"	slower.
Kansas City, Mo.,	"	19	"	"
Louisville, Ky.,	"	18	"	faster.
Macon, Ga.,	"	29	"	"
Minneapolis, Minn.,	"	13	"	slower.
Mobile, Ala.,	"	8	"	faster.
Nashville, Tenn.,	"	13	"	"
New Orleans, La.,	"	exactly the same.		
Omaha, Neb.,	"	24	minutes	slower.
Port Huron, Mich.,	"	30	"	faster.
St. Louis, Mo.,	"	1	"	slower.
St. Paul, Minn.,	"	12	"	"
Savannah, Ga.,	"	36	"	faster.
Selma, Ala.,	"	12	"	"
Sioux City, Iowa,	"	26	"	slower.
Terre Haute, Ind.,	"	10	"	faster.
Vicksburg, Miss.,	"	3	"	slower.
Winona, Minn.,	"	7	"	"

COMPARED WITH ONE HUNDRED AND FIFTH MERIDIAN TIME.

Denver, Colorado, time is exactly the same.

Laramie, Wyoming Territory, time is 6 miuutes slower.
Salt Lake City, Utah Territory, " 28 " "

COMPARED WITH ONE HUNDRED AND TWENTIETH MERIDIAN TIME.

Kalama, Washington Territory,	10	minutes	slower.
Portland, Oregon,	10	"	"
San Francisco, California,	10	"	"

SECTION LX.

UNIFORM TRAIN SIGNALS.

"There are three great principles under which all well managed roads are sought to be governed, viz.: Safety, efficiency and economy; and all of these will be promoted by the adoption of a uniform system of signals."

The General Time Convention, held in Chicago, October, 1883, took unanimous action on the question of the adoption of a system of uniform train signals for use upon the railways of the United States and Canada.

At this convention a committee of prominent managers made an excellent and carefully prepared report, as the result of close investigation of the subject, and believe that the system they have recommended is the best that can be devised for general use.

"The report discusses in a very clear and practical manner hand and lamp signals, bell cord signals, whistle signals, stationary signals, switch targets, danger signals for rear protection, and torpedo signals, and recommends a code in each case, which is based on careful study and experience and on the practice, generally, of the greatest number of roads."

Present indications point to the adoption of the new system proposed, which will no doubt ere long take the place of the present arbitrary and widely differing methods, to the great advantage of the railway men of the country.

In view of this fact we herewith present the following summary from the official pamphlet, issued by the National Railway Publication Company under instructions from the General Time Convention, which clearly states the principles upon which the system was formulated, and fully illustrates the plan proposed.

Fundamental Principles covering the form and use of Signals.—In considering the question, the committee arrived at the conclusion that there were certain fundamental principles covering the formation and use of signals which should never be lost sight of.

First.—Hand and lamp signals should be as nearly as possible like the motions a person uninstructed would give to convey the same meaning.

Second.—All signals should be so plain as to make it impossible to misunderstand or confuse them.

Third.—As far as possible, no signal should be made to convey more than one meaning.

Fourth.—Signals should be exhibited in the location which will make them the most plainly visible, and for the longest time, to those for whose information they are displayed.

In ascertaining the relation which the above principles bear to common practice, the committee decided that the time and labor that would be required to prepare statistics showing the practice of all the roads in the United States would be so great as to render it impracticable, and therefore (taking into consideration the train mileage and equipment) twenty-five roads were selected (except for switch signals) representing nearly 50 per cent. of the total train mileage of the United States, 33 per cent. of the equipment and 25 per cent. of the track mileage, and in making their recommendations, have endeavored to reconcile them with the practice as shown by these statistics and their own view of what is consistent with the principles they have assumed to be correct.

Hand and Lamp Signals.—To avoid confusion these signals should be made so that it is possible to give the same motion at night when the lamp is in the hand. There are four communications or signals necessary to be made in that manner, viz.: "Go ahead," "Stop," "Back up," "Train parted."

The motions made to convey these ideas should be as near like those made by an uninstructed person to produce the same movement as possible.

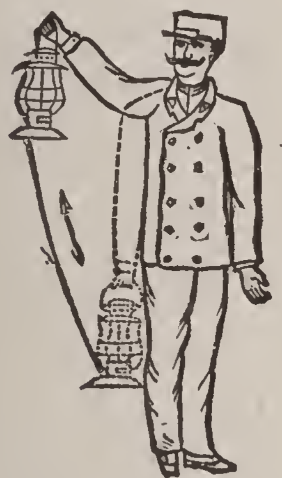
Persons giving signals are more frequently behind the engine than elsewhere, and the motions should be formed for that

position. The examination of the dozen or more persons with no railroad experience, assuming them to be placed behind the engine, resulted in a majority of the cases in motions resembling the following:

"Go ahead."—An up and down motion.

"Stop."—A motion crosswise with the track

"Back up."—A motion in a circle.



(FIG 22) GO AHEAD.

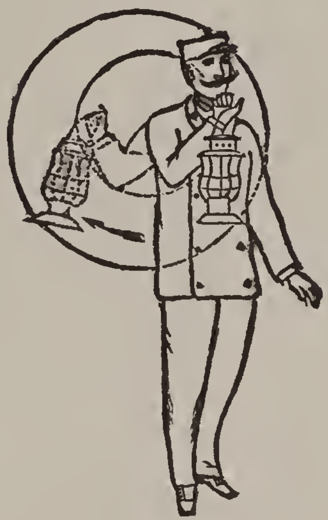
(FIG 23) STOP.

The go ahead signal was given by raising the hand above the head and moving it energetically forward in the direction it was decided to move the train, until the arm took a horizontal position, when the hand was again raised and the motion repeated. Looked at from the front, the hand has the appearance of moving up and down. (Fig. 22.)

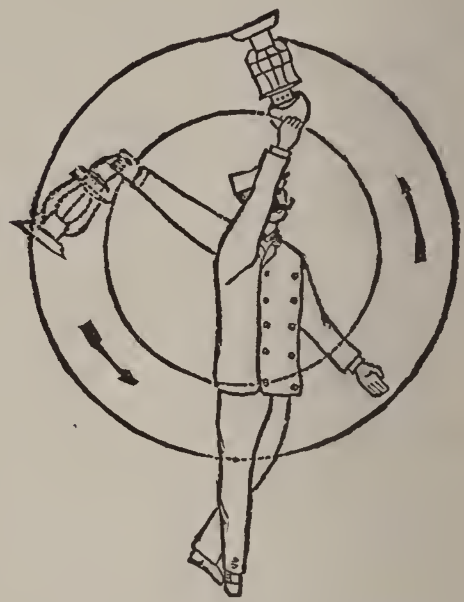
The signal to stop was made by moving one or both arms violently across the supposed line of movement. (Fig. 23.)

The back up signal was made by standing facing the engine, extending the arm towards the engineer, and moving it in the are of a circle over the head, at the same time slowly twisting the body until the hand is pointed almost in the direction the train was to move. The arm was then dropped and returned to the first position. The plane of the circle thus made was at an angle of about 45 degrees to the track, and the hand described

the complete circle, every point of which was visible from the engine. (Fig. 24.)



(FIG 24) BACK UP.



(FIG 25) TRAIN PARTED.

Train parted.—A motion in a verticle circle at arms length across the track, given continuously until answered by the engineer. (Fig. 25.)

No examination was made for a movement to indicate "train parted," as it is a matter of technique which cannot be understood by the uninitiated.

Bell Cord Signals.—Having considered hand and lamp signals, which are methods of transmitting information from a train crew to an engineer, we will continue the subject by the consideration of bell cord signals, which are for the same object.

In transmitting these signals correctly, it is very desirable that they should be made as brief as possible, and thereby reduce the liability for errors to a minimum.

1 tap, "Start."—Train standing.
2 taps, "Stop."—Train running.
2 " "Call in flagman."—Train standing.
3 " "Stop at next station."—Train running.
3 " "Back up."—Train standing.
4 " "Reduce speed."—Train running.

The above signals are recommended in accordance with com-

mon practice, as shown by the statistics, except the signal of "stop immediately," which has been deviated from for the reason that this signal is also the result of the train parting, and, if then obeyed by the engineer, would probably result in a collision with the detached portion.

Whistle Signals.—In considering these signals the committee has been enabled to use much more extensive statistics than in the other class of signals, by reason of the very full table published with the September edition of the "Official Railway Guide" for the year 1881.

The committee has deviated from the custom almost generally in use (two short blasts), believing that two long blasts is better for a signal to start, and that two short blasts should be used by the engineer to answer conductors, flagman's and others' signals.

The committee also deviates from the general custom in recommending four long blasts of the whistle to call in the flagman.

They not only think that four long blasts answer the purpose better, but that it is the common practice, notwithstanding the general rules on the subject to the contrary.

On many roads it may not be deemed advisable to adopt any signal to send a flagman out, but, when thought necessary, the committee recommends the use of five short blasts, when, from some sudden emergency, the engineer considers it necessary to notify the flagman that the rear of the train must immediately be protected.

Whistle Signals Recommended.—

Signals.	Meaning.
—	......Signal for approaching stations, railroad crossings and junctions.
o	..... Apply brakes; stop.
— —	......Off breaks; start.
o o	......Answer to any train, except train parted.
— — —	......Train parted.

(S) o o o	......Back up.
(R) o o o	......Calling attention to signals carried.
— — — —	......Call in flagman.
o o o o	......Engineer's call for signals from switchmen, watchmen and trainmen.
— — o o	......Road crossing.
o o o o o	......Send flagman out.
Succession of ☞o	..... Stock alarm.

Explanation of signs:—o short sound; — long sound; (S) slow pulls; (R) rapid pulls.

Stationary Fixed Signals.—The efforts of the committee have been directed to make *red* a signal of *danger only*, and to be used for no other purpose, whatever, than to bring trains to a full stop.

All signals of color, shape or position, not held in the hand, but placed stationary and by the side of the track, or affixed on a moving train, are included under this heading.

The principal use of such signals is to indicate either Danger! Stop! (*red*); Caution! Proceed with care! (*green*); Safety! Track clear! (*white*), or, if scheduled to do so, Stop for traffic! (*white and green*).

The fixed signals on trains have other meanings and will be considered hereafter.

Each of the four first-mentioned should be indicated by a signal of shape or color entirely distinct from all the others; and as colors are not readily distinguishable at a distance they should always, when practicable, be reinforced by shape or position.

Shape of Signals.—A man standing by a track, desiring to stop a train, would naturally extend his arm across the track. The outlines would be a perpendicular object with a horizontal arm protruding at right-angles near its top. If he desired to give no signal he would drop his hands and his outline would be perpendicular.

The signal of *danger* and *safety* should conform to these outlines as near as possible, and be combined with red and white at night.

The sign that would naturally suggest itself as one of *caution* would be a compromise between *danger* and *safety*, or a perpendicular object with an arm extending out and down at an angle of 45 degrees, and combined with green at night.

In conformity with the fourth principle mentioned in the first part of this report, all signals should be placed on the engineer's side of the track, as he approaches them, unless the land contours making them more easily seen by the engineer if placed on the other side.

Switch Targets.—Switch targets should be placed on the engineer's side as he runs towards the point of the switch, as there is more danger when running in that direction than when through the switch.

In case separate signals for trains, running in each direction, are placed on the same standard, the arm on the right side as the signal is approached should ordinarily govern the movement.

Signals for trains in one direction only ordinarily project from the right side of the upright as you stand facing it in the direc tion of the target.

Danger Signals for Rear Protection.—These signals should be displayed in an elevated position to the rear only, and never shown when the target is not on the main track.

The fixed signals on trains are used to indicate :

"Train following with the same rights as the train carrying the signals."

"Train following, which is irregular, or extra."

"Train carrying the signals, itself irregular," rear of the train and for rear protection.

The committee recommend a *green* signal carried on the

front of the engine to indicate a "train following with the same rights as the train carrying the signals."

A combined *green* and *white* signal carried on the front of an engine to indicate a "train following which is irregular."

A *white* signal carried on the front of an engine to indicate that the "train carrying the signal is itself irregular."

The rear of every train (passenger or freight) should be plainly marked to enable those interested to know that *all* of the train has passed; and that *green* signals be used for this purpose which should be combined with red signals so that one lamp can serve both purposes.

Torpedo Signals.—(1) "Danger!" "Stop!" (2) "Caution!" "Run carefully!"

The signal for danger should consist of fewer detonations than the one for caution, so that if one cap fails to explode in a "caution" battery, the signal becomes one of danger.

Concerning the Use of Signals.—The committee recommend that a danger signal be used to indicate "Train orders."

Trains on sidings should clear and remove their signals of danger and display those of caution, otherwise trains passing on the main track will be stopped.

The rear of a train is the part that, when the train is proceeding in its authorized direction, will pass over a given point last, and markers should be displayed at that point, and no train should be reported or considered by until the markers are seen.

SECTION LXI.

TELEGRAPHIC AND RAILWAY NOTES.

Operating rooms in large cities.—The operating rooms of the Western Union—and sometimes of other companies—in cities, are located on the top floor of the buildings occupied. First-class operators are assigned regular wires. Second-class, or inferior operators, have charge of one or more "way" wires. The manager of the operating room has charge of all chief and sub-chief operators, as well as of operators and check clerks. A "wire chief" has charge of all wires, locates "grounds," "crosses," "escapes," etc. Chiefs have charge of "squads" of operators and checks, and sub-chiefs have supervision of a certain number of operators forming a squad. Operators appear for duty at the hours assigned them, and must be *on time.*

Way wires.—Wires which run through and connect with small towns over which the business of the same is transmitted, the volume of which is not large.

"*Regular,*" *or* "*heavy wires.*"—Wires running to the great Commercial Centers of the Country on which the amount of business transacted is enormous.

Rates, additional words.—

When the rate for 10 words is	25	30	35	40	45	50	55	60	65	70	75	80	85	90	1.00
The rate for each additional word is	2	2	2	3	3	3	4	4	5	5	5	5	6	6	7

Insuring honesty of the employes of railway companies.—"It is a fact not generally known that the railway companies are, one and all, taking steps to insure the honesty of their employes. Hitherto all officials who have handled any large sums

of money belonging to their companies have usually given a bond signed by one or more friends, men who were known to be substantial. In case the bonds were forfeited, the companies have often found it wiser to compromise than to take action against the persons who signed the paper, as by so doing they incurred no one's ill-will and did not bring their road into unpopularity, and perhaps lose ten times over the amount of the shortage. Then again, when a bond for a large amount was signed by an active business man, he would be shown by the person whom he thus favored courtesies which could not be extended to all shippers. In this way the railway management was often embarrassed, both by honest and dishonest employes. In order to obviate these difficulties railway companies have now recourse to the different guarantee companies which are located in this country and Canada. In all large stations the cashiers give security, the guarantee company charging nominally three-fourths per cent. on the amount of the bond. Half of this sum is borne by the company and half by the employe. At the small stations the agent of the company is himself required to furnish security. This system is used by the Pennsylvania company, by the roads generally throughout the West and Northwest, and to some extent by Eastern lines, and it looks as if it was destined to become universal in a few years."

Average number of railway employes.—The census volume pertaining to transportation, issued in 1884, shows the average number of employes per annum engaged upon the railroads of the United States to be as follows:

General officers	3,375
General office clerks	8,655
Station men	63,380
TRAIN MEN.	
Engineers	18,977
Conductors	12,419
All others	48,254
Total	79,650

SHOP MEN.

Machinists	22,766
Carpenters	23,202
All others	43,746
Total	89,714
Track men	122,489
All other employes	51,694
Aggregate	418,957

Salary—The aggregate average salary is $41.12 per month, the highest being paid by the Central Pacific, $63.21 per month, and the lowest by the Chicago, Burlington & Quincy, $32 per month, the average of the Pennsylvania Railroad being $41.72.

The plan of paying employes by check is increasing in favor with the railway companies, and it will not be many years before all have adopted it.

Advantage of the "check" or "draft system."—"The system is advantageous in many respects. It protects the paymaster from mistakes in counting out money, and consequent loss out of his own pocket. Instead of receipting the roll, the employe's receipt on the back of the draft answers the purpose and the draft furnishes a complete and concise record of the transaction. The advantage to the employe lies in the fact that he will be compelled to go to the bank and draw his money, and a familiarity with banking affairs and a balance left for them once at the bank may lead men to start a bank account who have heretofore spent their money as rapidly as they have earned it."

The largest railway system in the world.—"The vast railway system formed by the consolidation of the Missouri Pacific and Wabash, St. Louis & Pacific lines has a total mileage of 9,658 miles—by far the greatest combination under one management in the world. The roads composing it are as follows: The Missouri Pacific railway; Central Branch Union Pacific railroad; Missouri, Kansas & Texas railway; St. Louis, Iron Mountain & Southern railway; Texas & Pacific railway; International & Great Northern railroad; Galveston, Houston & Henderson railroad; Wabash, St. Louis & Pacific railway."